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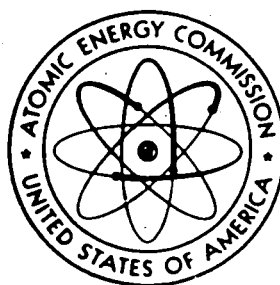
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# PROJECT RULISON

## MANAGER'S REPORT

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APRIL 1973

UNITED STATES ATOMIC ENERGY COMMISSION  
NEVADA OPERATIONS OFFICE

Las Vegas, Nevada

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## PREFACE

The Rulison project, detonated September 10, 1969, was the second nuclear detonation designed to determine the economic and technical feasibility of using nuclear explosives to stimulate an underground, low-productivity natural gas reservoir.

The project was part of the Atomic Energy Commission's (AEC) Plowshare program for developing peaceful application of nuclear explosives and was sponsored by the Austral Oil Company, Incorporated (AUSTRAL) of Houston, Texas; the AEC; and the U.S. Department of the Interior. Program management for Austral was provided by the CER Geonuclear Corporation (CER) of Las Vegas, Nevada.

The project site is located in the low-productive, gas-bearing Mesaverde formation in the Rulison field of west central Colorado. The experiment, using a  $43 \pm 8$ -kiloton (kt) device, was detonated at a depth of 8,426 feet in the Piceance Creek Basin.

This report is concerned with the administration, operational planning, safety, engineering, construction, and logistics performed by the AEC/NV in support of the technical and scientific experiments conducted under Project Rulison through the postshot reentry program and the production test phase.

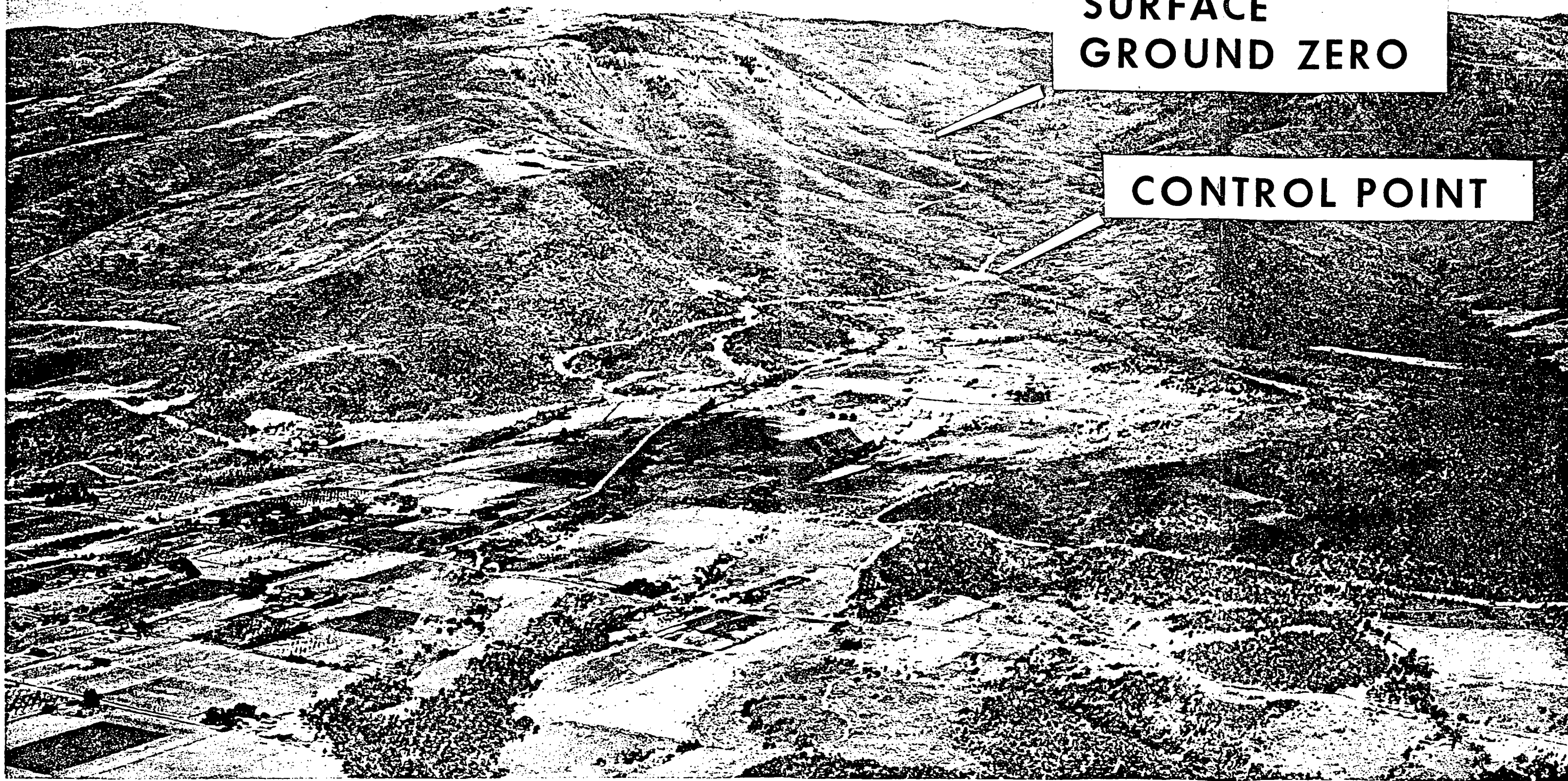
This report includes a summary of technical and scientific information available at the time of publication. More detailed information can be found in the documents listed in "Reports Available in Plowshare Open File," NVO-86 (Rev. 2).



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SURFACE  
GROUND ZERO

CONTROL POINT



R U L I S O N   S I T E

Figure - 1

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# ABBREVIATIONS

Listed below are abbreviations for agencies and government contractors that participated in Project Rulison.

Air Resources Laboratory--Las Vegas . . . . .	ARL-LV
Albuquerque Operations Office (AEC) . . . . .	ALO
Austral Oil Company, Incorporated . . . . .	AUSTRAL
Battelle Memorial Institute . . . . .	BMI
CER Geonuclear Corporation of Las Vegas, Nevada . . . . .	CER
Defense Nuclear Agency (formerly DASA) . . . . .	DNA
Division of Applied Technology . . . . .	DAT
Division of Peaceful Nuclear Explosives (Now DAT/PNE) . . . . .	DPNE
Eberline Instrument Corporation . . . . .	EIC
EG&G, Inc. . . . .	EG&G
Environmental Protection Agency (formerly USPHS) . . . . .	EPA
Environmental Protection Agency--National Environmental Research Center (formerly EPA/WERL) . . . . .	EPA/NERC
Environmental Protection Agency--National Environmental Research Center-Las Vegas (formerly EPA/WERL-LV) . . . . .	EPA/NERC-LV
Environmental Research Corporation . . . . .	ERC
Fenix & Scisson, Inc. . . . .	F&S
General Adjustment Bureau, Inc. . . . .	GAB
Holmes & Narver, Inc., On-Continent Test Division . . . . .	H&N-OCTD
John A. Blume & Associates Research Division . . . . .	JAB
Lawrence Livermore Laboratory (University of California, formerly LRL) . . . . .	LLL
Los Alamos Scientific Laboratory (University of California) . . . . .	LASL
National Oceanic and Atmospheric Administration--Air Research Laboratory (formerly ESSA/ARL) . . . . .	NOAA/ARL

National Oceanic and Atmospheric Administration--Air Research Laboratory-Las Vegas (formerly ESSA/ARL-LV) . . .	NOAA/ARL-LV
National Oceanic and Atmospheric Administration--Earth Sciences Laboratory (formerly USC&GS and ESSA/C&GS) . . . .	NOAA/ESL
Nevada Operations Office (AEC, formerly NVOO) . . . . .	NV
Oak Ridge National Laboratory . . . . .	ORNL
Office of Information Services (formerly OPA) . . . . .	OIS
Office of Peaceful Nuclear Explosives (Now PAD) . . . . .	OPNE
Radiological Operations Division . . . . .	ROD
Peaceful Applications Division . . . . .	PAD
Peaceful Nuclear Explosives . . . . .	PNE
Reynolds Electrical & Engineering Co., Inc. . . . .	REECo
Sandia Laboratories (formerly Sandia Corp.) . . . . .	SL
San Francisco Operations Office (AEC) . . . . .	SAN
Teledyne Isotopes, Inc. . . . .	Isotopes
Test Evaluation Panel (Now CEP) . . . . .	TEP
U.S. Atomic Energy Commission . . . . .	USAEC
U.S. Bureau of Mines . . . . .	USBM
U.S. Bureau of Reclamation . . . . .	USBR
U.S. Geological Survey . . . . .	USGS
University of Nevada, Las Vegas . . . . .	UNLV
Waterways Experiment Station (Corps of Engineers) . . . . .	WES
Wackenhut Services, Inc. . . . .	WSI

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## CHAPTER I

### PLANNING, AUTHORITIES, AND ORGANIZATION

#### 1.1 BACKGROUND

Austral became interested in the use of nuclear explosives to stimulate gas reservoirs early in 1965 and began evaluating properties which might be amenable to this approach. They found that the Mesaverde formation in the Rulison field of west central Colorado appeared to be a suitable area for nuclear stimulation since, from known drilling and testing data, the underlying reservoir rocks contained an estimated eight trillion cubic feet of natural gas at depths ranging from 6,200 to 8,700 feet beneath some 60,000 acres. The permeability of the reservoir rocks is so low that conventional production stimulation methods seemed impractical and uneconomical.

Austral acquired approximately 20,000 acres from various operators and options on an additional 20,000 acres. At Austral's request, CER conducted a surface site tour in the early winter of 1965 and confirmed that the site had potential for a nuclear shot due to its remoteness and formation depth in which a nuclear explosive could safely be detonated. Work was started immediately on preparing a detailed nuclear stimulation feasibility study and additional leases were obtained and two test wells were drilled. Upon completion of these wells in the spring of 1966, Austral/CER carried out an extensive well testing program to accurately determine the gas in place and more accurately define the producing characteristics of the Mesaverde reservoir.

The project site is in Garfield County about six miles southeast of the town of Grand Valley, Colorado. Elevation of the emplacement well (R-E) is 8,154 feet above sea level. (See Figures 1 and 2.)

The Rulison experimental program was divided into three phases. Phase I included drilling the preshot exploratory hole (R-EX) and the R-E; performing preshot gas-production tests; and conducting geological, hydrological, and other studies for technical and safety confirmation.

Phase II included surface construction, emplacement of the explosive, detonation, and measurements of immediate detonation effects. This phase was completed with the detonation of a  $43 \pm 8$ -kt yield nuclear explosive on September 10, 1969. The explosive was emplaced at a depth of 8,426 feet through a 10 3/4-inch steel casing that was then filled to the surface with stemming materials for containment purposes.

A delay of seven months occurred before reentry. During this time, the radioactivity in the underground cavity created by the explosion decayed to less than one thousandth of that present 12 hours after the detonation.

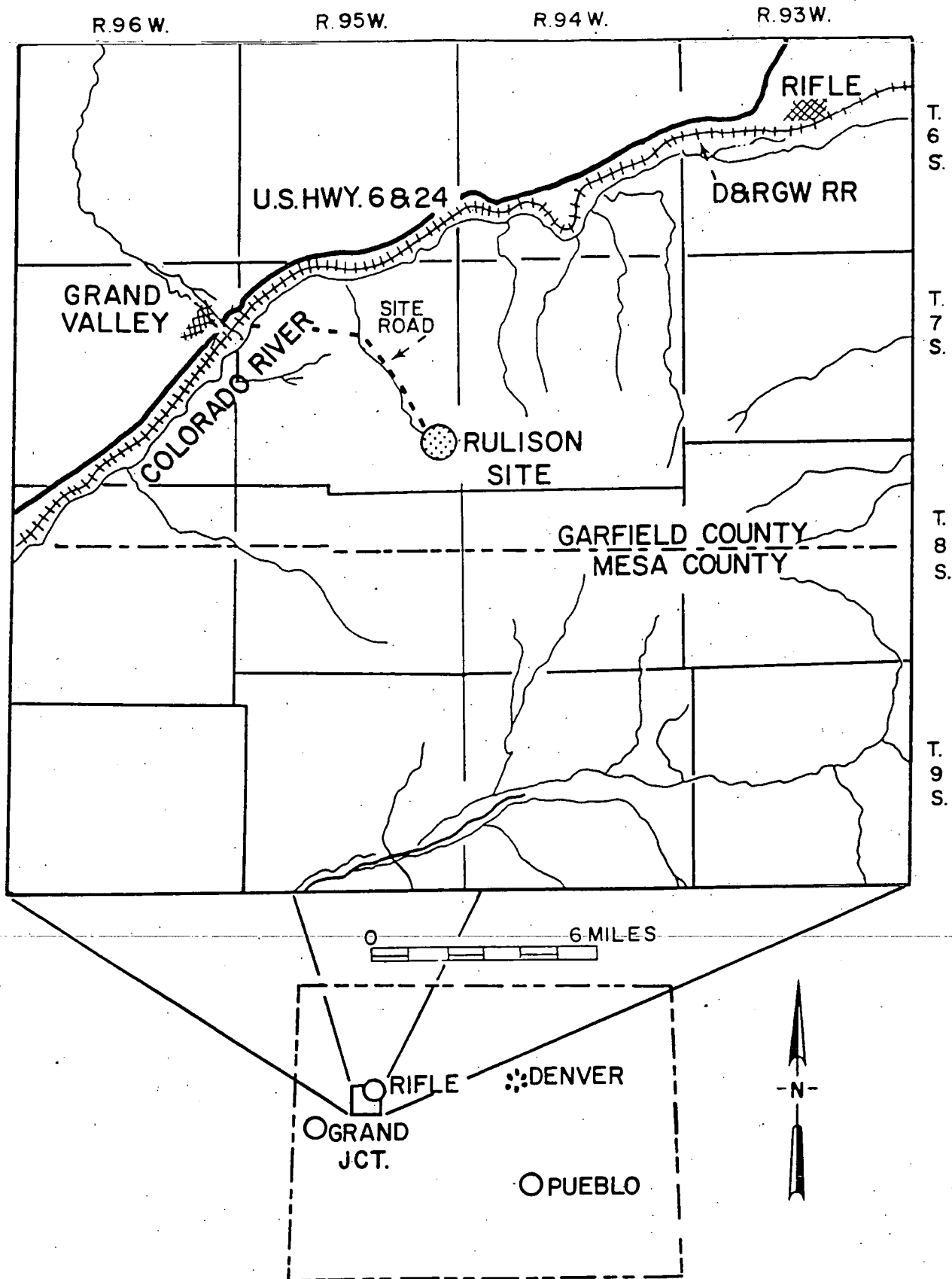


FIGURE 2. INDEX MAP OF THE PROJECT RULISON SITE



Phase III of the experiment, initiated in April 1970, involved controlled drillback into the chimney followed by flow testing of the gas to determine the cavity size and the rate and volume at which the natural gas could be produced.

Detailed descriptions of the experiment are contained in the Project Rulison Definition Plan, dated March 26, 1969, the Project Rulison Post-Shot Plans And Evaluations (NVO-61), dated December 1969 and in the Effects Evaluation for Project Rulison (NVO-43), dated June 1969.

## 1.2 OBJECTIVES

The specific technical objectives of the project were: 1) to measure the changes in gas production caused by the nuclear explosion; 2) to measure the effective flow capacity of the nuclear fracture zone with time and decreasing reservoir pressure; 3) to determine the gas quality with regard to contamination by radioactivity and techniques that can be utilized in reducing this contamination; 4) to identify the effective height and volume of the chimney and the effective fracture zone radius as determined by production testing; and 5) to evaluate seismic effects produced by the detonation, thus providing information on appropriate yields for any future development.

## 1.3 CHRONOLOGY

Project Rulison was proposed by Austral and CER in a letter addressed to the Chairman, AEC, dated July 29, 1966. The companies provided AEC with a feasibility report which proposed the detonation of two 50-kt nuclear explosives suspended in a drill hole at depths of 7,500 to 8,500 feet. A preliminary review of the proposal was made by AEC's San Francisco Operations Office (SAN), in conjunction with the Lawrence Livermore Laboratory (LLL) and the U.S. Bureau of Mines (USBM). The reviewed proposal was given to the AEC's Division of Peaceful Nuclear Explosives (DPNE), on December 5, 1966. Austral and CER made a formal presentation of their proposal before the Commission on December 6, 1966, and on February 17, 1967, restated their plans before the Joint Committee on Atomic Energy.

During the spring and summer of 1967, Austral and CER developed a tentative Operational Plan for Project Rulison in cooperation with LLL, USBM, and the U.S. Geological Survey (USGS). This plan, released for preliminary government review on November 27, 1967, differed from the concept contained in the feasibility report by: 1) substituting a single nominal 60-kt nuclear explosive (subsequently reduced to a nominal 40-kt yield by joint agreement) for the original idea of two 50-kt explosives and 2) including the exploratory hole specifications.

In late July 1967, Austral constructed a 3 1/4-mile graded road from Morrisania Mesa to the proposed site. The road was completed in early October.

On October 4, 1967, Austral and the USGS executed the Rulison Unit Agreement which recognized the time frame necessary to complete the experiment.

The contract for drilling the first exploration hole for Project Rulison was signed on November 1, 1967, and the well was spudded on November 9, 1967.

In April 1968, the Director, DPNE, designated the Los Alamos Scientific Laboratory (LASL) as the AEC scientific laboratory responsible for providing the nuclear explosive for Project Rulison and requested the AEC Nevada Operations Office (NV) to coordinate development of the total project plan. To assist in accomplishing its mission, NV developed, in coordination with CER, general procedures for obtaining the material required for detailed project definition.

In May 1968, the drilling of the R-EX was completed and reservoir tests and evaluations were started. Drilling of the R-E was begun by Austral in late September 1968. By January 1969, the well had been drilled to a total depth of 8,701 feet and coring, logging, casing, and cementing activities were completed. Preliminary site preparations at the surface ground zero (SGZ) and the control point (CP) locations were begun.

Consistent with the Plowshare objective of increasing industry's participation in project activities, Austral and CER took the lead role in preparing plans, schedules, estimates, and forecasts of requirements. The NV and the other government participants provided requirements, planning assistance, and critically reviewed the plans as they were developed. In this manner, the detailed project definition was completed in December 1968.

In January 1969, the Manager, NV, submitted the plan, together with his project analysis, to DPNE recommending authorization be given to enter contract negotiations. During February 1969, a contract was negotiated and submitted for management review by all parties involved. Following the signing of the Rulison contract on March 26, 1969, all project preparations, including effects evaluations and public relations activities, were targeted toward meeting a May 1969 detonation date. However, in April 1969, it became apparent that additional time might be required to complete the safety studies and on April 14, 1969, a public announcement was released by NV to this effect. In early May, based on potential problems related to the Harvey Gap Dam and other safety-related matters, the Manager, NV, in consultation with Austral and other major participants, recommended that detonation be rescheduled from May 22, 1969, to early September 1969. A new detonation date of September 4, 1969, was announced on July 16, 1969.

In late August and early September 1969, three suits were filed for preliminary injunctions against the Rulison detonation. During this period, hearings were held in the Federal District Court of Colorado with subsequent findings allowing the project to proceed.

The Rulison execution was delayed due to unfavorable weather conditions from September 4 to September 10, 1969, when the nuclear explosive was detonated at 3 p.m. Mountain Daylight Time (MDT). There was no release of radioactivity to the atmosphere and the resultant ground motion was essentially as predicted.

#### 1.4 POSTSHOT ACTIVITIES

The Rulison Claims Office in Grand Valley was opened by the AEC on September 11, 1969, and closed on November 14, 1969. From that time to the deadline date of September 10, 1970, complaints were handled either by the General Adjustment Bureau (GAB) in Grand Junction or directly by the AEC in Las Vegas. Chapter XV contains information on private property damage complaints.

Following the detonation, the site was deactivated and placed in a standby condition awaiting decay of short-lived radioisotopes prior to chimney reentry. A document titled Project Rulison Post-Shot Plans And Evaluations (NVO-61) was issued by NV in December 1969 which discussed detailed plans for postshot operations and evaluations.

Five gas samples (about 150 standard cubic feet each) were obtained by LLL from the R-E on January 9, 1970. Subsequent analyses indicated that the samples were not representative of the chimney gas.

Subsequent to the Court's decisions to permit the Rulison detonation in September 1969, plaintiffs sought permanent injunction against the AEC to prohibit flaring of gas. A trial was held from January 12 to 16, 1970, in Denver on the matter. On March 16, 1970, a decision was received which permitted AEC and Austral to reenter the Rulison chimney and undertake the flaring program set forth in NVO-61.

Postshot reentry site preparations began April 1, 1970, and required about two weeks longer to complete than estimated because of bad weather and the necessity for engineering modifications. Reentry into the R-EX hole began on April 28, 1970, and by May 26, 1970, the hole was milled to a depth of 6,517 feet. At that point on June 1, 1970, directional drilling was started toward the chimney, and on June 29, 1970, the 5 1/2-inch casing liner was cemented in place to a depth of 7,624 feet. Directional drilling was completed to a total measured drill string depth of 8,354 feet (192 feet above detonation point) on July 28, 1970.

Calibration flaring was scheduled to start on August 18, 1970; however, the hole plugged after initial flow tests were made on August 18 and 22, 1970. To remedy the condition, a drill rig was brought in and downhole operations were underway by September 11, 1970, and the hole was cleaned out by September 29, 1970.

Reentry operations were completed on October 4, 1970, and calibration flaring was reinitiated on October 4. This phase of flaring was completed on October 7, 1970. A total of 12.9 million cubic feet (MMCF) was flared in this period.

The high flow-rate production testing phase began on October 26, 1970, and continued to November 3, 1970, when the well was shut in for a short term buildup period. A total of 109.5 MMCF was flared in this test. The intermediate production flow test began December 1, 1970, and was completed on December 20, 1970. A total of 99.9 MMCF of gas was flared. The third, and final, flow test began on February 2, 1971, and ended on April 23, 1971. The total gas flared in the third test was 233 MMCF.

The site was placed on standby status in mid-May 1971 in conformance with the Rulison Standby Plan and consistent with criteria and guidance provided by DPNE. Site activity has been limited chiefly to taking periodic measurements of pressure buildup.

The Rulison site continued on standby status until July 1972, at which time a general site cleanup operation was initiated. The site was cleaned up to criteria furnished by AEC/HQ<sup>1</sup> and as outlined in the NV "Project Rulison Radiological Operations Rollup Plan" July 1972.

#### 1.5 SITE INVESTIGATION AND EVALUATION

During 1967, LLL, CER, and Austral personnel developed criteria for site selection, inspected the proposed site area, and prepared drilling specifications for the exploratory well. Findings of the site reconnaissance trip follow.

"The site is served by a 16-foot wide all-weather road that connects with the county-maintained paved road near the Morrisania Mesa Community Center. In case of effluent release, the road network on Morrisania Mesa is adequate and safe.

"Communication facilities can be built at and near the site. A radio sending antenna and power supply can be developed adjacent to the access road approximately one-half mile north of SGZ. Radio repeating towers can be located on Doghead Mountain or on the east-west trending nose northeast of the site. Either of these locations are in line of sight to Grand Valley and could be used for a full-scale commercial development if the project is successful.

"Grand Valley could serve as a control point if the radio is used for transmitting firing and communication data. This location is logistically attractive since Grand Valley is located on the railroad and Interstate 70--U.S. 6-24.

<sup>1</sup>Memorandum, Kelly/Miller, dated April 17, 1972. "Radiological Safety Guidance for Experiments Involving Nuclear Stimulation of Natural Gas Wells."

"Morrisania Mesa and the Colorado River Valley (Grand Valley area) have adequate power. Commercial telephone service is available at Grand Valley as well as at the site area."

#### 1.5.1 Criteria

The following criteria was necessary for selecting a reservoir stimulation test site where a nuclear device could possibly be detonated:

- a. A site where technical data enumerated in the project objective could be obtained.
- b. A site where the hydrologic situation is such that it is not probable during postshot testing and production of the reservoir that water, either from overlying aquifers or edge water, will be introduced into the chimney environment in such quantities as to compromise the experiment.
- c. A site where the reservoir rock contained adequate gas reserves. This was determined by analyses of the core, logs, and the R-EX production test results.
- d. A site that would completely contain a nuclear explosion.
- e. A site where all AEC safety and operational criteria could be met.

#### 1.5.2 Location of the Site

The Rulison field comprises approximately 60,000 acres in the south-central portion of Garfield County, partly overlapping the northeast portion of Mesa County. The boundary of the approved Federal Unit lies south of the Colorado River and extends upward from an elevation of about 5,200 feet near the river up the slopes of Battlement Mesa to an elevation of over 10,000 feet.

The site, located in the southern part of the field, is on the upper reaches of Battlement Creek on the north slope of Battlement Mesa. The site elevation is approximately 8,200 feet, and the valley is open to the north-northwest and is bound on the other three sides by steep slopes rising above 9,600 feet. The region is covered with grass, cedar, Engleman spruce, fir, and aspen on the upland and by sagebrush and range grass in the lower elevations.

The SGZ for the Rulison experiment was in Section 25, Township 7 South, Range 95 West. Also, the SGZ was adequately served by a 16-foot wide graveled road that connects with the county-maintained road system. Locations of the R-E and R-EX are shown on Figure 3.

The nearest city with commercial airline connections is Grand Junction, population about 22,000, approximately 40 miles to the southwest. The nearest city with substantial industry is Rifle, population about 2,200, approximately 12 miles to the northeast. The nearest town, Grand Valley, has a population of around 245 and lies about 6 miles northwest of SGZ.

The area is served by the Denver and Rio Grande Western Railroad with sidings at both Grand Valley and Rifle. The area is also served by a two-lane highway, U.S. 6-24. A local road system with two 10-ton capacity bridges, one near Grand Valley, the other at the settlement of Rulison, furnish access across the Colorado River.

The population of the immediate Rulison area is confined principally to the valleys of the Colorado River, Plateau Creek, a tributary to the Colorado River, and adjacent mesa lands. About 220 persons live between 3.5 and 5 miles from SGZ, and about 1,500 additional persons live between 5 and 10 miles from SGZ. No permanent habitation exists closer to SGZ than 3.5 miles.

The economic base of the immediate area is provided by the Union Carbide plant at Rifle, the Oil Shale Corporation plant in Parachute Creek, the railroad, the raising of livestock, and the cultivation of orchards and livestock feed.

## 1.6 ORGANIZATION RESPONSIBILITY

The major assignments of responsibilities for Project Rulison are listed below:

### 1.6.1 AEC

DPNE was responsible for the direction of AEC Plowshare programmatic activities, general policy development and guidance, and coordination with other AEC and federal organizations at Headquarters level. DPNE was also responsible for the AEC project-related funding requirements including the nuclear explosive and associated detonation services.

NV was responsible for the management and control of nuclear operations including activities associated with providing for public health and safety and for administering certain AEC responsibilities delegated to the Manager, NV, by the

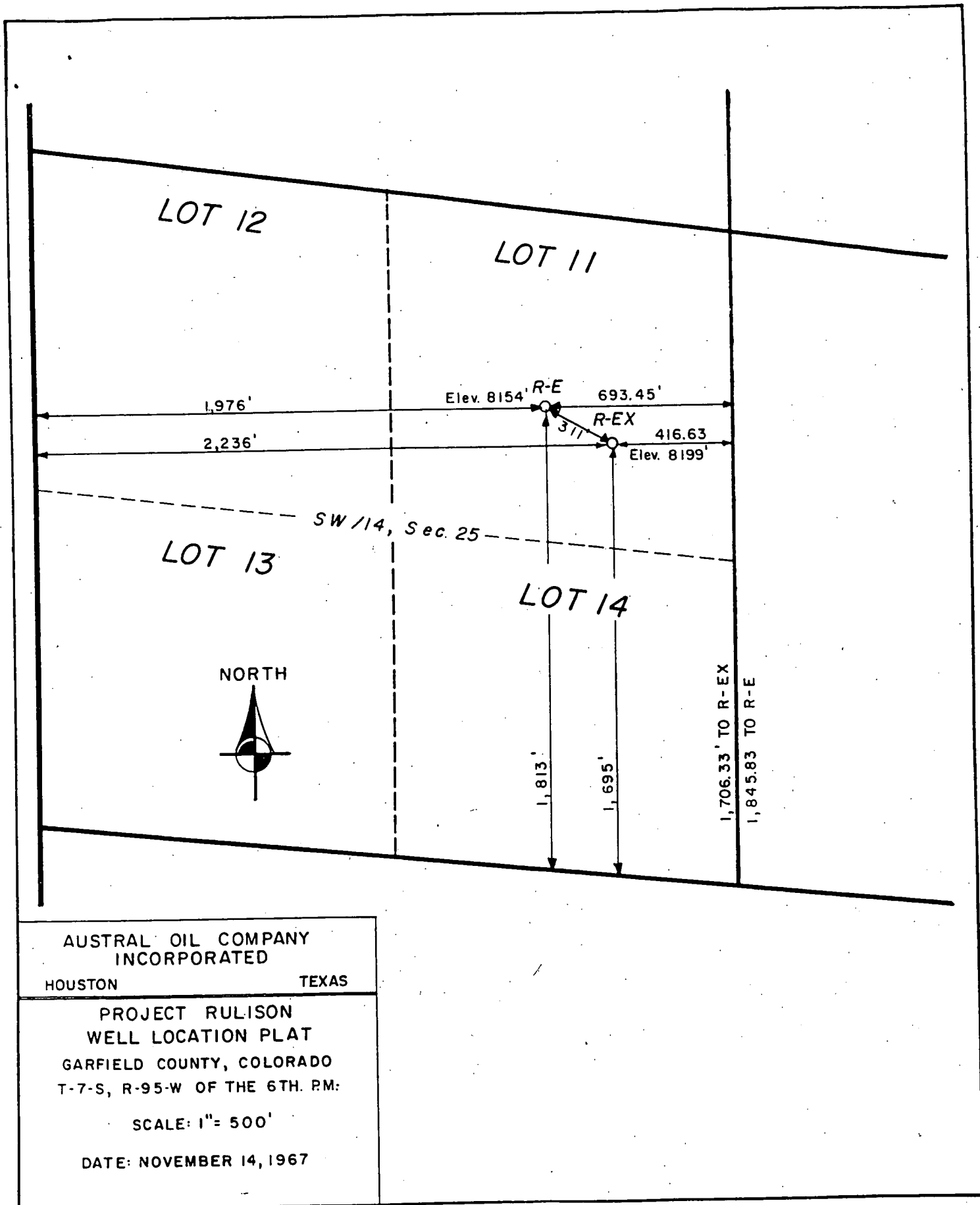


FIGURE 3. LOCATION OF R-E AND R-EX

Contracting Officer under the provisions of the Rulison contract. The Test Manager, NV, served both as the Director of Nuclear Operations (DONO) and the Contract Administrator and was responsible for project control during operational periods.

The Project Rulison contract was renegotiated and AEC took over additional responsibilities such as offsite radiological safety.

#### 1.6.2 Austral

Austral, on its own or through its CER Program Manager, was responsible for providing and funding: 1) the project area; 2) all construction, including the R-EX, the R-E, and post-shot reentry and related programs; 3) general technical and logistical support; 4) management of field activities (excluding critical nuclear safety, technical, and operational functions); and 5) its participation in the evaluation of the experimental results.

#### 1.6.3 CER

CER was responsible for all subcontracts that were not the responsibility of the government agencies, except those that Austral elected to let (e.g., the drilling contract for post-shot activities). CER provided the Project Director, the Site Manager, the Chairman for the Technical Committee, and other project personnel.

#### 1.6.4 Department of the Interior

USBM was responsible for the government agencies' review, design, participation, and evaluation of the gas-stimulation aspects of the experiment. USBM also was responsible for coordinating activities that involved other offices and bureaus within the Department of the Interior and for serving as liaison representative for the Department in matters pertaining to Rulison. Under existing arrangements with NV, USBM evaluated the pre- and postshot conditions of mines, oil wells, and gas wells in the vicinity of the project for safety-related purposes.

USGS assisted and advised in the definition of geologic and hydrologic aspects relative to technical and safety considerations under existing interagency agreements with NV. USGS also provided supervision of drilling, testing, and production operations in accord with Federal Regulations (30 CFR 221), the Rulison Unit Agreement, and advised on leasing arrangements and similar matters for which it had responsibility.



Other offices and bureaus within the Department, e.g., the Solicitor and Bureau of Land Management, were available for assistance within their areas of responsibility.

#### 1.6.5 LASL

LASL was responsible for providing the nuclear explosive, the arming and firing system, and for technical supervision of the emplacement and stemming of the nuclear explosive. The Operations Director (OD) and staff, furnished by LASL, armed and fired the nuclear explosive on the command of DONO, NV, and provided technical assistance during drillback.

#### 1.6.6 Project Management Concept

Austral, on its own behalf and through its Program Manager, CER, was responsible for fielding and managing the project. Functions related to the nuclear explosive system and the control of nuclear-related safety and security activities were the responsibility of the AEC through NV and LASL.

Essentially, the field organization consisted of a Project Director, assigned by CER, who was assisted by other CER staff members, including a chairman for the Technical Committee and a Site Manager. The Project Director was responsible to CER for the overall coordination of engineering, construction, support, technical evaluation, and management of the project. He was in charge of coordinating all preshot project activities, except during nuclear operations when the AEC's DONO assumed control. During the detonation period, the Project Director was responsible for providing the necessary support and assistance required by DONO to safely conduct nuclear-related activities.

The Project Rulison Technical Committee was chaired by a CER representative who reported to the Project Director. In addition to CER, the Committee included representatives from the Department of the Interior, the AEC, LASL and Austral. The Technical Committee was responsible for reviewing and evaluating data; formulating and revising technical plans; and recommending activities, procedures, and techniques which were required to meet the technical objectives. Their principal interest was in pre- and postshot reservoir evaluation activities.

The Site Manager, assigned by CER, was responsible to the Program Manager for site construction, support, communications, and general site management in accordance with a plan approved under the Rulison Unit Agreement, except for those functions related to nuclear operations which were the responsibility of the DONO and the LASL Operations Director. The Site Manager served as the contact for the

DONO Engineering and Logistic Representative on matters relating to modification and implementation of government and laboratory field construction and support requirements.

The Manager, NV, established a Rulison Advisory Group consisting of senior representatives from the Department of the Interior, LASL, LLL, and NV to advise him and the industrial participants upon their request on matters relating to the development of the Project Rulison. Acting at the request of the Manager, the Advisory Group provided advice and recommendations pertaining to technical, operational, or safety problems.

During reentry and initial flaring, the radiological safety responsibility was delegated to the OD by DONO. The OD was responsible to DONO to make certain that the radiological safety program was conducted within criteria established.

Eberline Instrument Corporation (EIC) provided radiological safety support to DONO and to the OD as required.

The Environmental Protection Agency/National Environmental Research Center (EPA/NERC) was responsible for providing a public radiological safety program as directed by DONO. The Air Research Laboratory in Las Vegas (ARL-LV) was responsible for providing forecasts of meteorological conditions and predictions of radiation movement and dispersion, also under the direction of DONO.

## 1.7 BOARDS AND PANELS

### 1.7.1 Test Evaluation Panel (TEP)

The TEP, now called the Containment Evaluation Panel, and alternates consisted of:

R. H. Thalgott, NV, Test Manager  
W. W. Allaire, NV, Deputy Test Manager  
Charles I. Browne, LASL, Associate Division Leader  
Robert R. Brownlee, LASL, Staff Member  
Harry L. Reynolds, LLL, Associate Director  
Larry S. Germain, LLL, Associate Division Leader  
Byron F. Murphy, Sandia Laboratories (SL), Director of  
Underground Experimentation  
Carter D. Broyles, SL, Department Manager  
Col. J. J. Neuer, Defense Nuclear Agency (DNA), Director,  
Test Operations (to July 1968)  
Col. J. T. Jones, DNA, Director, Test Operations (since  
July 1968)  
Col. R. C. Holmes, DNA, Deputy Director, Test Operations  
Clinton S. Maupin, Reynolds Electrical & Engineering  
Co., Inc. (REECo), Medical Consultant

Melvin W. Carter, EPA/NERC-LV, Director, EPA/NERC-LV  
Alan Moghissi, EPA/NERC-LV, Chief, Radiological Research,  
EPA/NERC-LV  
John R. McBride, EPA/NERC-LV, Deputy Director, EPA/NERC-LV  
Phillip W. Allen, National Oceanic and Atmospheric Admin-  
istration (NOAA) ARL-LV, Chief, ARL-LV  
Harold F. Mueller, NOAA/ARL-LV, Chief, Radioactivity,  
Estimates, & Research Branch, ARL-LV

The primary responsibility of the TEP was to review all data pertinent to containment aspects of each planned nuclear test, then based on these data, assign the test to one of the risk categories, Category A, B, or C. The meetings held were as follows:

- a. July 16, 1968--The containment aspects of the industrial Flowshare Project Rulison, cosponsored by LASL/CER, was formally discussed by the TEP at this meeting. Categorization was deferred until more information was received and a more complete review could be made.
- b. March 24, 1969--At the forty-second TEP meeting, a presentation was made by CER on the emplacement hole R-E and the exploratory hole R-EX. The presentation concerned itself primarily with the drill hole construction, i.e., narrative interpretation of caliper and similar logs, hole histories, and matrix (distances, bearing, size, and depth) of nearby holes out to a distance of about 2,000 feet.

There was concern by some of the Panel members as to the integrity of the wellhead equipment on the Rulison emplacement hole. The Panel requested that a ground shock analysis be performed of this equipment, and upon completion of this analysis, submit it to the Panel members. The Panel was polled as to the category classification of Rulison and agreed upon Category A-Conditional, subject to review of the wellhead equipment.

Between the forty-second and forty-third meetings of the TEP, the Panel evaluated the stemming plans and wellhead configurations by correspondence.

- c. May 26, 1969--At the forty-third meeting of the TEP, a request was made that the configuration of the wellhead, "Christmas tree," be further reviewed to see if some of its mass could be reduced.
- d. August 14, 1969--At the forty-fourth meeting, a revised Austral drawing depicting the changes in the wellhead configuration was reviewed by the Panel and approved, thus removing the conditional constraint attached to

the TEP categorization "A." This meeting was the final TEP meeting held to evaluate the containment aspects of Rulison.

#### 1.7.2 Nuclear Safety Study Group

A Nuclear Safety Study was conducted in Los Alamos, March 5, 6, and 13, 1969, to evaluate those operations planned for the Rulison event that were under the cognizance of the Manager, Albuquerque Operations Office (ALO). Members present were:

W. A. Earl (Chairman), Weapon Safety, ALO  
T. E. Wade, Nuclear Safety, NV  
R. F. Sullivan, Technical Services, SAN  
R. W. Drake, GMX-DO, LASL  
D. R. Lewis, Weapon Safety, SL  
A. W. Lundberg, Advanced Systems, LLL

The following meetings were held:

- a. March 5, 1969--The group reviewed the design and assembly of the Rulison nuclear explosive, and its transportation to the Rulison site in Colorado. The Study Report was approved by the Assistant Manager for Operations, ALO.
- b. March 12-14, 1969--The same Nuclear Safety Study Group, with T. E. Wade, NV, acting as Chairman, met in Los Alamos to evaluate those operations planned for the Rulison event that were under the cognizance of the Manager, NV. Operations evaluated by this Study Group included the ground zero activities, the emplacement, and the firing system for the Rulison nuclear explosive. The Study Report was approved by the Manager, NV, on April 25, 1969.

The Study Group made an inspection of the Rulison site on April 24 and 25, 1969. No further recommendations concerning nuclear safety were made to the Manager, NV, and Nuclear Safety Study Group action was considered complete.

#### 1.7.3 Panel of Consultants

This panel consisted of:

G. B. Maxey, U. of Nevada, Hydrogeologist  
L. S. Jacobsen, Private Consultant, Structural Engineer  
N. M. Newmark, U. of Illinois, Civil Engineering  
D. U. Deere, U. of Illinois, Civil Engineering & Rock Mechanics  
T. F. Thompson, Private Consultant, Engr. Geologist  
L. G. von Lossberg, Sheppard T. Powell & Associates, Hydrology  
S. D. Wilson, Shannon & Wilson, Inc., Soil Mechanics and Foundation Engr.

The following meetings were held by these consultants:

- a. February 27, 1969--On this date, a preliminary review of Project Rulison was made. However, because the evaluation and plans were incomplete at that time, the Panel concluded that additional studies were needed to formulate a firm statement on the project.
- b. April 11, 1969--At this meeting, the Panel indicated that required safety analyses had been properly performed. It also noted that the planned operational precautions were sufficient to avoid hazard to the public. However, the Panel recommended that mines, to a distance including the Dutch Creek Mine, be investigated and the material properties of Harvey Gap Dam be analyzed to preclude a possible failure.
- c. May 1, 1969--A further review of the stability of Harvey Gap Dam was made by the Panel with the following recommendations:

Alternate 1: Postpone the shot until such time as the reservoir is lowered by irrigation withdrawals to a level at least 15 feet below crest elevation. Provide for timely post-shot evacuation of people downstream if circumstances warrant.

Alternate 2: Lower the elevation immediately by discharging and wasting water such that the reservoir level is lowered to 15 feet below the crest. Provide for timely post-shot evacuation of people downstream if circumstances warrant.

Alternate 3: Lower the water elevation to 10 feet below the crest and provide stockpiles of sand and gravel with loading equipment at the dam so that cracks can be quickly repaired. Evacuate people during the event from that area downstream that could be flooded by uncontrollable discharge of the reservoir over a several hour period.

- d. May 5, 1969--By separate letter, consultant Stanley D. Wilson, after discussion with the Bureau of Reclamation and confirmation by telephone with other Panel members, concluded that the Rifle Gap and Vega Dams posed no hazard from the event.

Based on the above recommendations by the Panel and other operational considerations, the Rulison detonation date was rescheduled from May to early September. The following

meeting, therefore, was the final preshot evaluation made by the Panel prior to detonation.

- e. July 25, 1969--The lowered water levels in dam reservoirs for the revised (September) detonation date and additional data concerning Battlement Mesa satisfied the Panel that the event could be executed safely.

#### 1.7.4 Project Rulison Advisory Group

This group consisted of:

W. E. Ogle, Chairman, LASL, Scientific Advisor  
H. L. Reynolds, LLL, Scientific Advisor  
J. W. Watkins, USBM, Director of Pet. Research  
F. W. Stead, Alternate, USGS, Research Geologist  
R. T. Johansen, Alternate, USBM, Project Coordinator  
R. H. Thalgott, NV, Test Manager  
M. D. Nordyke, LLL, Technical Advisor  
Ben Bowyer, NV, Executive Secretary

The following meetings were held:

- a. September 27, 1968--This group met on this date to review progress relative to project planning.
- b. June 4, 1969--Again the group met to recommend a new readiness date of September 4, 1969.

#### 1.7.5 Ad Hoc Rulison Review Panel

This Panel was formed by the Manager, NV, to review data concerning predictions and evaluations of the bioenvironmental and engineering aspects of Rulison reentry, gas reservoir testing, and flaring. The Panel consisted of the following persons:

<u>Name and Title</u>	<u>Organization</u>
B. W. Beebe, Vice President	MM&B, Inc. Natural Gas Consultants Boulder, Colorado
Leo K. Bustad, Director	Radiobiology Laboratory School of Veterinary Medicine University of California Davis, California
T. B. O'Brien Production Manager	Roden Oil Company Midland, Texas

Leonard A. Sagan, M.D.  
Associate Director

Department of Environ-  
mental Medicine  
Palo Alto Medical Clinic  
Palo Alto, California

Vincent Schultz  
Professor of Zoology

Washington State  
University  
Pullman, Washington

This Panel met on November 20 and 21, 1969, and again on December 22, 1969. They concluded that Project Rulison could be accomplished within acceptable safety standards.

1.7.6 Project Rulison Advisory Panel

Members of this panel included:

R. H. Thalgott, NV, Test Manager  
R. L. Aamodt, LASL, Scientific Adv. (Chairman)  
M. W. Carter, EPA/NERC-LV, Dir., EPA/NERC-LV  
P. W. Allen, NOAA/ARL, Chief, NOAA/ARL-LV  
C. S. Maupin, REECO, Med. (Rad) Consultant  
R. D. Maxwell, Chief, Nuclear Explosive Environment  
Safety, Division of Operational Safety, AEC/HQ  
F. D. Cluff, NV, Rulison Safety Officer (Meteorology)

The Panel met in April and August 1969 and reviewed project plans. The Panel met in Grand Junction between September 4 and 10 to interpret and advise the Test Manager on detonation conditions.

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## CHAPTER II

### SCIENTIFIC ACCOUNT

#### 2.1 SCIENTIFIC MEASUREMENTS

##### 2.1.1 Background

Many organizations have published measurements of Project Rulison. LLL is preparing a summary report of this data and their interpretations.

##### 2.1.2 Rock Composition

The R-E core from 8,400 to 8,462 feet (below ground level) was chemically and mineralogically analyzed by LLL. This Mesaverde formation contains impure sandstone, siltstone, and shale. Some average values of special interest are: 1) carbon dioxide = 5.2 weight percent, 2) bound water = 2.2 weight percent, 3) lithium = 32 parts per million (ppm), 4) boron = 64 ppm, and 5) mercury = 50 pp billion. Calcite is the major carbonate mineral and makes up about 12 weight percent of this core.

##### 2.1.3 Equation of State Measurements and Calculations

LLL measurements of the strength of the R-E core sandstone, together with additional information from the logs, were used in a computer calculation of the effects of the Rulison explosive on the gas-bearing formation. The cavity radius ( $R_c$ ) was calculated to be 76 feet, shear fractures extended to 276 feet ( $3.6 R_c$ ), and the maximum extent of fracturing was 433 feet ( $5.7 R_c$ ). These calculated figures agree well with the  $R_c$  of 78 feet calculated from krypton-85, and the fluid loss encountered 275 feet above the working point.

On April 20, 1971, the apparent length of the Rulison firing cable was electronically measured. It was found to be open at a point 498 feet ( $6.5 R_c$ ) above the detonation point. This is only 65 feet beyond the zone of fracturing determined by computations.

#### 2.2 NUCLEAR EXPLOSIVES OPERATIONS

##### 2.2.1 The Nuclear Explosive

The nuclear explosive utilized for Project Rulison was produced by LASL. It was a fission device that yielded  $43 \pm 8$  kt. The nuclear explosive itself was contained in a downhole package approximately 9 inches in diameter, 17 feet long, and weighing approximately 1,250 pounds. (See Figure 4.)

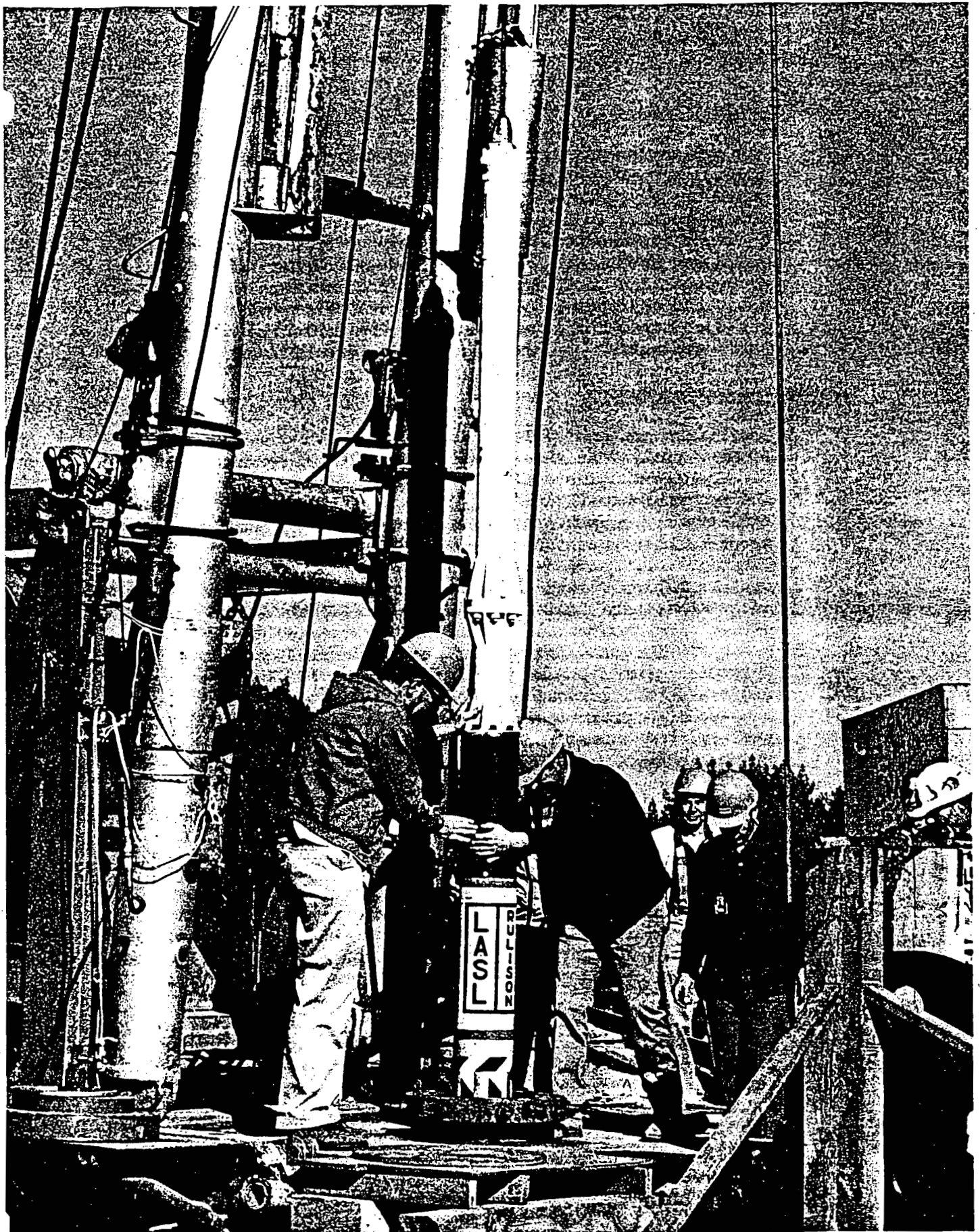


FIGURE 4. EMLACEMENT OF DEVICE

### 2.2.2 Canister Emplacement

The explosive canister was emplaced using an Amerigraph cable, Type 34JIXB, which contained the electrical circuits to the canister. The cable was run over a 36-inch sheave secured to the headframe at a working height of 20 feet. The downhole cable was wrapped on a winch drum which was specifically designed and tested for this application. The winch provided full-power control of the cable and canister at variable speeds during the lowering operation. Surface handling of the explosive and dummy canisters was accomplished with a mobile crane.

### 2.2.3 The Firing System

The firing system for the nuclear explosive consisted of a control trailer at the Rulison CP, a 2.6-mile surface run of a single multiconductor cable running downhole to the nuclear explosive. Electronic equipment located in the control trailer generated the necessary signals in the proper sequence and transmitted them to the nuclear explosive. The signal cable was used both for the operation of the nuclear explosive and for monitoring the explosive performance. Additional cables from the CP to SGZ were used for surface "environmental" measurements. The downhole cable was 0.719-inch Amerigraph double-armored cable, containing a coaxial center conductor, 32 conductors of No. 22 wire, and two layers (opposite lays) of steel armor. This cable was used to transmit signals to the nuclear explosive. The cable was also used to lower the nuclear explosive into the emplacement hole.

## 2.3 POSTSHOT OPERATIONS

### 2.3.1 Production Testing

Following the calibration flow period, three production flow tests were made to determine the postshot production characteristics of the Mesaverde formation in the interval stimulated by the nuclear explosive. Figure 5 shows the flow rates and volumes of gas produced for each of these test periods.

Approximately 456 million standard cubic feet (MMSCF) of gas, including certain diluents which were present, was produced from the nuclear-stimulated well in 108 days of flow testing. This volume is the equivalent of approximately 10 years of production from a conventionally stimulated well in the Rulison field. The 456 MMSCF of gas was saturated with water vapor at separator conditions and was diluted with carbon dioxide and hydrogen. The behavior of these diluents with time is described in Sections a and b.

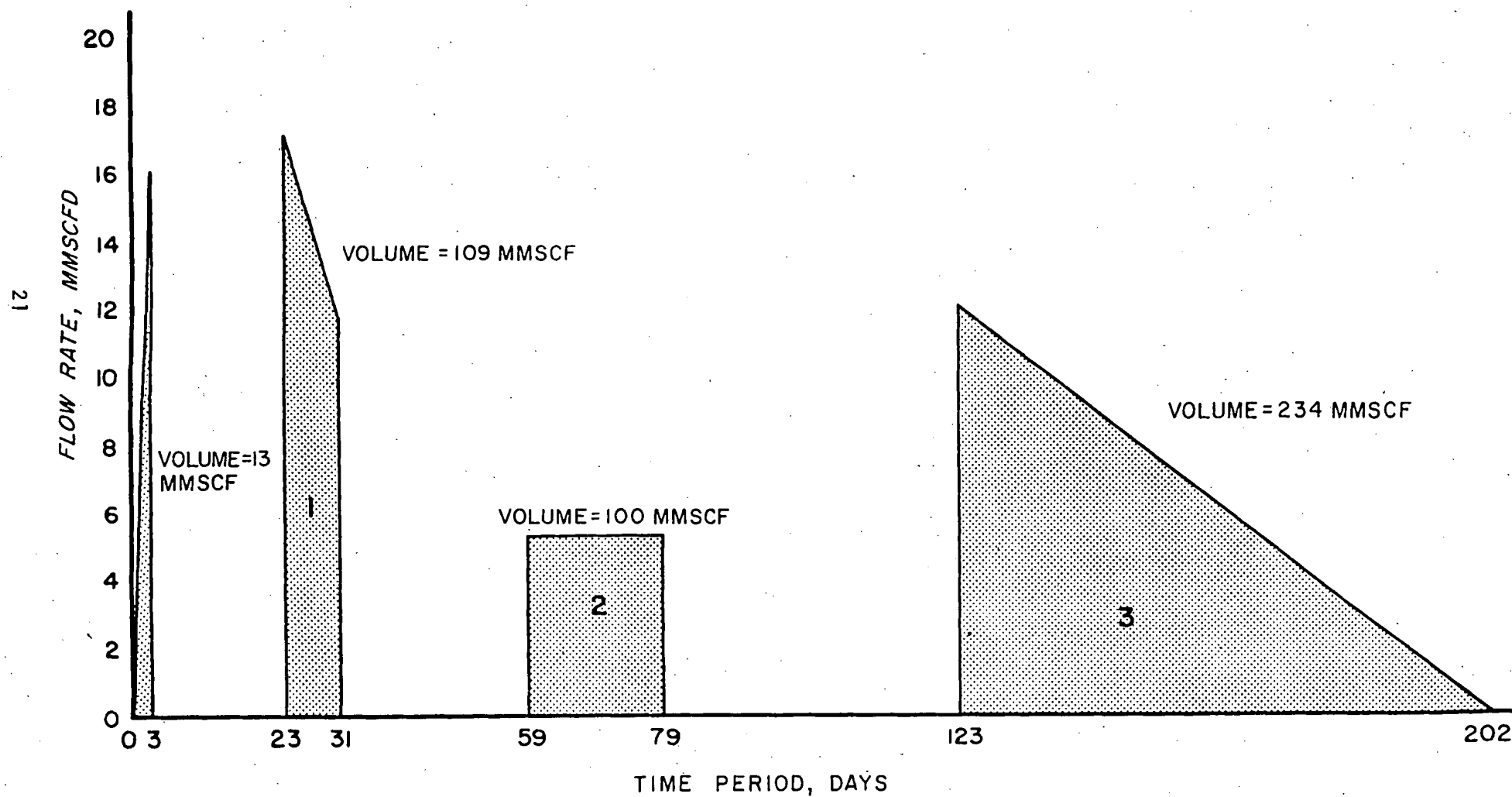


FIGURE 5. PROJECT RULISON FLOW TESTS

Subsurface pressure and temperature measurements were made at a depth of 8,200 feet, a point 154 feet above the bottom of the reentry well or 346 feet above the detonation point (see Figure 6). The first measurement was made on October 24, 1970, just prior to the first production test, and a shut-in pressure of 3,150 pounds per square inch gauge was recorded. These subsurface measurements could not be made during the calibration flow period, the first production test, or the early part of the third production test because of the high flow velocity in the tubing string. To complete the subsurface pressure data, daily pressures were computed from surface pressure measurements using observed subsurface pressures to calibrate the computations. A plot of the computed and measured bottom-hole pressures by days from the commencement of testing on October 4, 1970, until August 1, 1971, is shown in Figure 7.

Analysis of the bottom-hole pressures measured during the second production flow test indicated very little flow restriction through the penetrated fractures, thus confirming that an effective path between the chimney and the reentry wellbore had been established. This observation was particularly important because of the initial concern that the intersection of fractures only by the reentry wellbore might not be sufficient for production testing purposes. A simple pressure-volume-temperature analysis of these pressures also indicated a  $R_c$  of approximately 76 feet. This compares favorably with a radius of 78 feet obtained from krypton-85 data.

The maximum flowing subsurface temperature recorded in the flow string at 8,200 feet (346 feet above the detonation point) was 438°F.

#### a. Gas Analysis Data

Twelve gas samples were taken during the flow tests, and a complete chemical analysis of each was made to determine the percentage of the various methane series hydrocarbons present. Also, this analysis determined the concentration of the two primary diluents, carbon dioxide and hydrogen. These data plotted as mol percent concentration vs cumulative gas produced are shown in Figure 8.

Through the production of approximately 374 MMSCF of gas, the decline in concentrations of hydrogen and carbon dioxide were essentially parallel, accompanied by an increase of methane. However, the percentage of carbon dioxide began to increase very gradually to the end of the third production test. This increase was accompanied

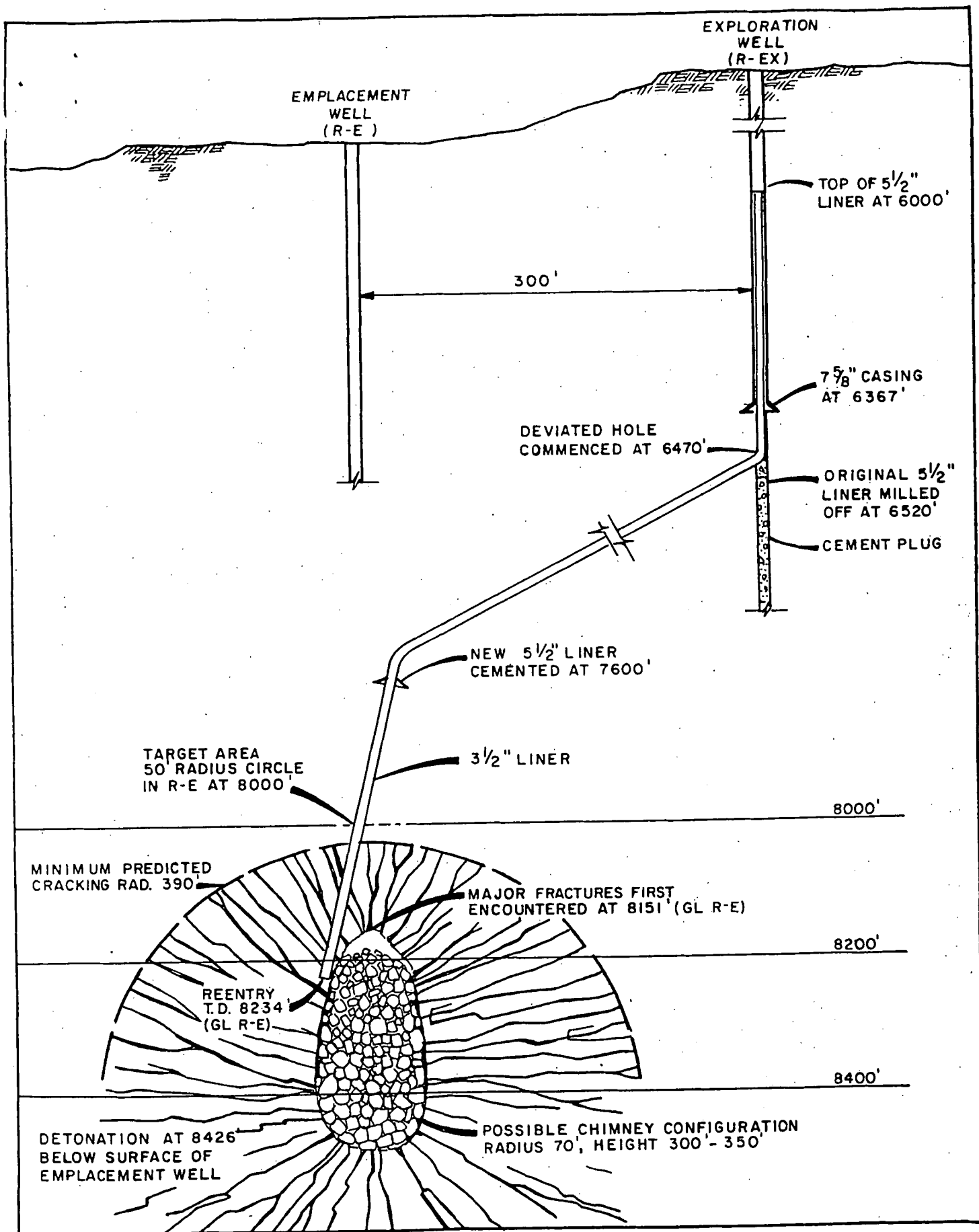


FIGURE 6. SCHEMATIC DIAGRAM OF REENTRY WELL

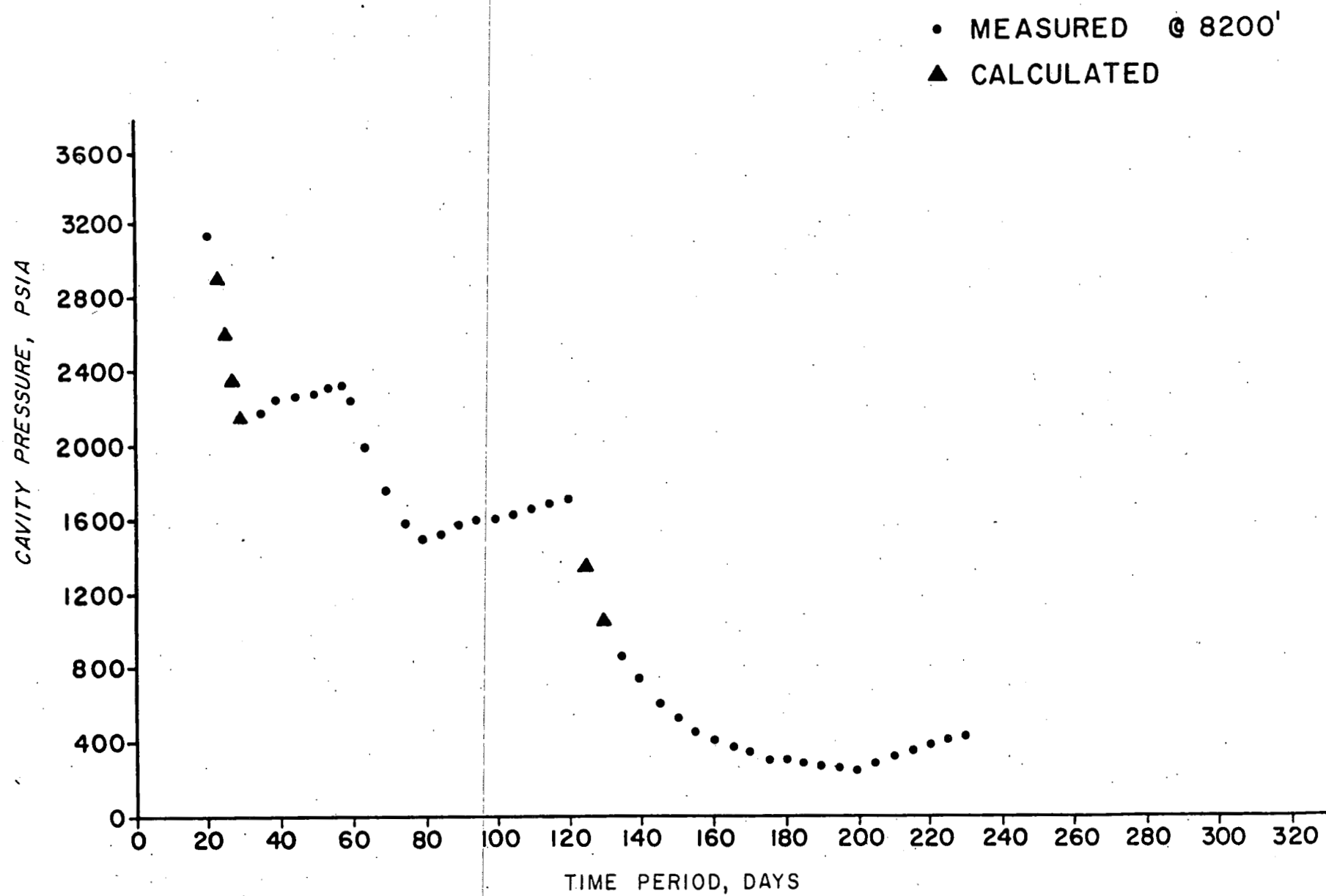


FIGURE 7. PROJECT RULISON CAVITY PRESSURES

by a corresponding decrease in the methane component. The interpretation of this behavior is discussed later under "Carbon Dioxide."

All of the gas samples mentioned above were also analyzed for certain radioactive components, including the two gaseous isotopes, tritium and krypton-85. Figure 9 shows the change in total tritium and krypton-85 concentrations with respect to cumulative gas production. The concentrations of these two isotopes declined in an expected manner and were only about 2 percent of their initial concentrations at the conclusion of flow testing.

The isotope mercury-203 was also observed in the Rulison gas. Chemical analysis of the formation rock near the point of detonation indicated that sufficient mercury was present naturally to produce the minute concentrations of mercury-203 seen in the Rulison gas.

Early calculations were made to determine the initial concentration of krypton-85, assuming that uniform mixing of the gas and krypton-85 takes place. These results indicated a  $R_c$  of 72 feet. The results were based on the theoretical creation of 800 curies of krypton-85, the initial concentration of krypton-85 observed in the gas, 150 picocuries/cubic centimeters (pCi/cc), and the presumed reservoir pressure and temperature. Later calculations based on the observed release of 1,064 curies of krypton-85 and the observed reservoir pressure and temperature indicated a  $R_c$  of 78 feet. As previously noted, these dimensions compare very favorably with the pressure analysis results and the information developed by reentry drilling.

The yield of the Rulison explosive was subsequently calculated to be  $43 \pm 8$  kt based on the creation of approximately 1,113 curies of krypton-85 assuming  $25.8 \pm 3.9$  curies of krypton-85 were created per kt.

Only 2,824 curies of tritium were produced from the well during the flow tests. This is only about 28 percent of the theoretical 10,000 curies predicted to result from the nuclear explosion. Most of the gaseous tritium was removed from the cavity by the end of the testing, as shown in Figure 9. An accounting of all of the tritium created could not be made because of the large quantity of tritiated water still being recovered at the conclusion of testing and an unknown volume of water remaining in the cavity. A significant portion of the tritium remains bound in the solidified melt zone. It is believed that the boron carbide shield surrounding the nuclear explosive was probably effective in reducing the tritium produced by the



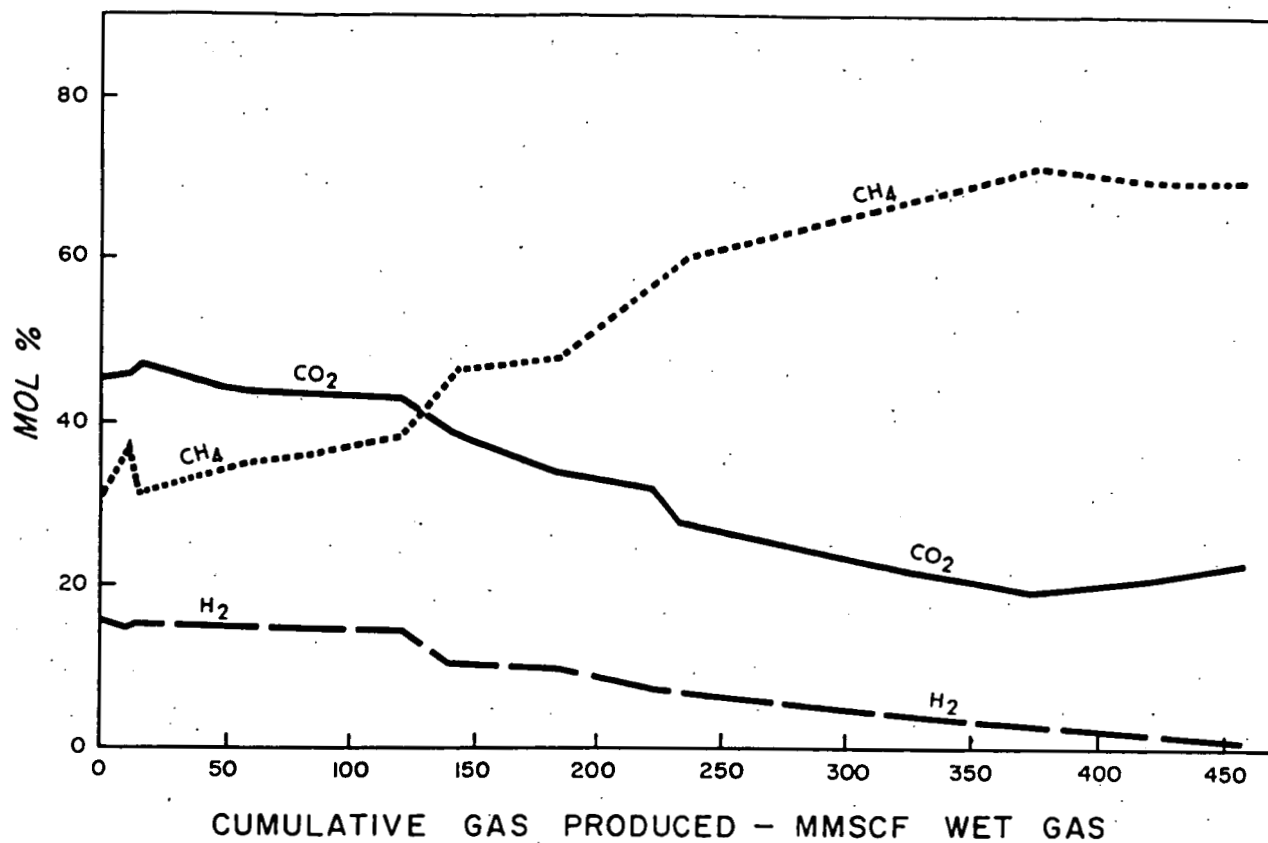


FIGURE 8. PROJECT RULISON CHEMICAL ANALYSIS DATA

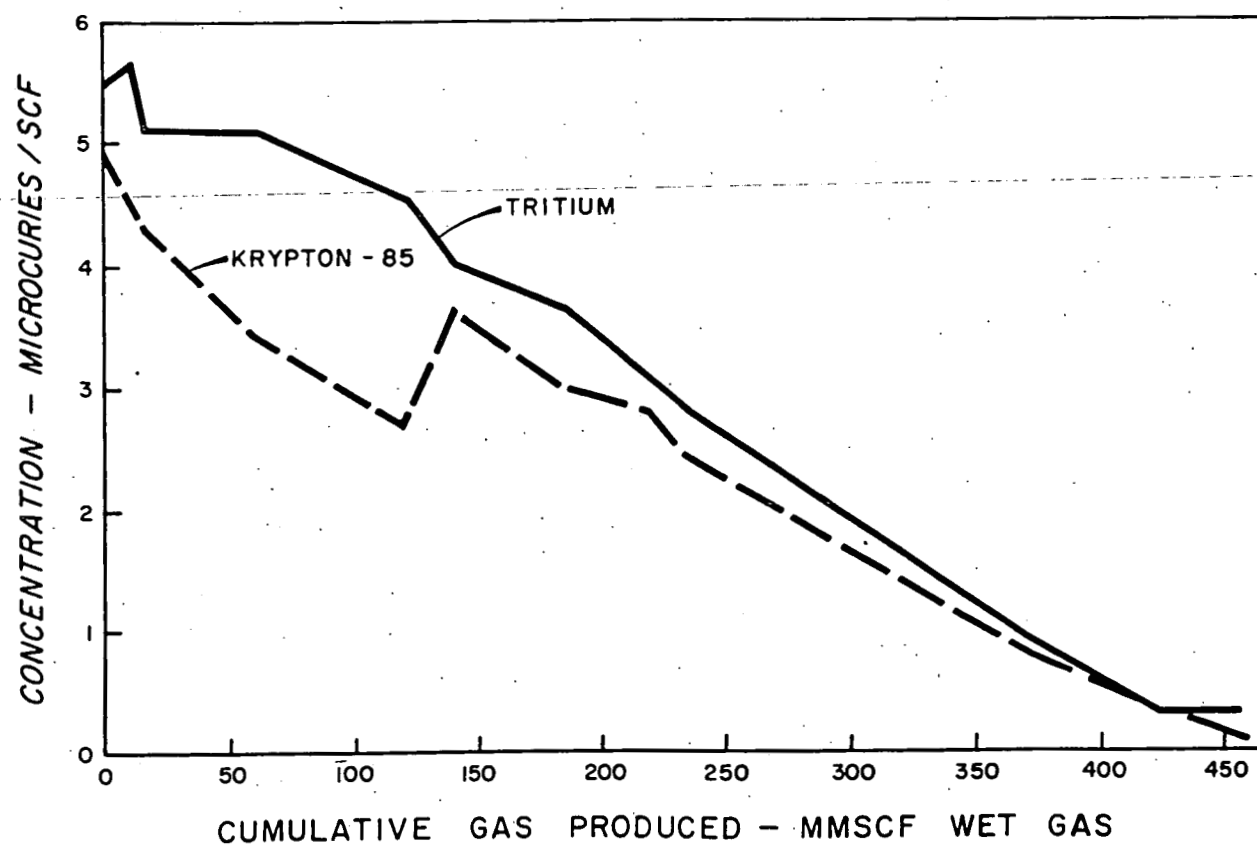


FIGURE 9. PROJECT RULISON RADIOCHEMICAL ANALYSIS DATA

explosion to below 10,000 curies, but the lack of a tritium balance has made it difficult to evaluate this effectiveness.

b. Evolution and Production of Water and Carbon Dioxide

(1) Water

The total volume of water initially in the chimney is believed to have been as much as 30,000 barrels. There has been no way, however, to accurately assess this initial volume. This water was originally contained in: 1) the pore space of the rock, both sand and shale, which was vaporized, melted, or heated by the nuclear detonation and 2) the drilling mud lost when the reentry hole was connected with the chimney. Approximately 15,000 barrels of water were recovered at the surface during the flow tests, and an additional calculated volume of approximately 6,000 barrels of water passed through the gas volume measurement system as vapor. At the conclusion of the third production test, approximately 170 barrels of water, liquid and vapor, were still being produced from the well with each MMSCF of methane gas and diluents (carbon dioxide and hydrogen) being produced. The concentrations of tritium in the produced water remained essentially constant throughout the flow testing, indicating no influx of new water from the producing formation.

As the pressure in the chimney declined, the absorptive capacity of the gas increased, allowing the gas to carry increasing amounts of evolving water vapor to the surface. A part of this vapor condensed in the separation equipment and was measured. The gas which left the separator was assumed to be saturated with water vapor. The amount of water leaving the separator equipment in the vapor phase was estimated using a published correlation of the absorptive capacity of natural gas by Katz, et al. This calculated amount of water vapor was added to the amount recovered as liquid to determine the total water content in the production stream. A total of 158 MMSCF of water vapor is estimated to have evolved in the cavity during the flow tests. As much as 50 MMSCF was counted in the flow measurements.

Figure 10 shows the daily total water produced per MMSCF of dry gas. A significant change in the rate of water production occurred as the chimney pressure approached 380-400 pounds per square inch absolute

(time period, 166-176 days). This is interpreted as the time when most of the water remaining in the chimney reached its vapor pressure and flashed into steam. Following this, it is believed that additional water continued to flash in the fractured zone as it also reached its vapor pressure. A chimney temperature of 440-445°F is indicated from this event. The temperature was somewhat greater than 450°F at the start of testing since heat was lost with the flowing gas and water and due to the expansion of gas.

As water vapor evolved in the chimney, it added to the volumetric withdrawal from the chimney and, at the same time, to the apparent influx of gas into the chimney. In addition, the vaporization of the water in the chimney created additional space available to gas, water vapor, and other diluents, although this volume is rather small.

## (2) Carbon Dioxide

As the well produced, the hydrogen concentration in the gas declined almost linearly with the cumulative gas production (see Figure 8). The carbon dioxide concentration, however, did not decline in this fashion. Logically, if all of the carbon dioxide and hydrogen were formed at the time of the detonation and were uniformly mixed in the vapor phase, both the carbon dioxide and hydrogen concentration should have declined similarly. The carbon dioxide concentration not only failed to decline commensurately with the hydrogen concentration, but actually began to increase after a cumulative production of about 375 MMSCF of gas (time period, 148 days). Most of the carbon dioxide was initially formed at the time of detonation with the possibility of a small amount being generated by the heat from the rock melt.

Figure 11 shows the measured separator gas gravity with respect to time and also reflects the later evolution of carbon dioxide. The rapid removal of carbon dioxide during the first and second flow tests (time periods, 23-31 days and 58-76 days) caused the initial decline in gravity. Once the cavity pressure was appreciably reduced, however, the excess carbon dioxide began to evolve faster than it was being removed and brought about a subsequent increase in gravity. The continued decline in hydrogen concentration also contributed to the gravity change.

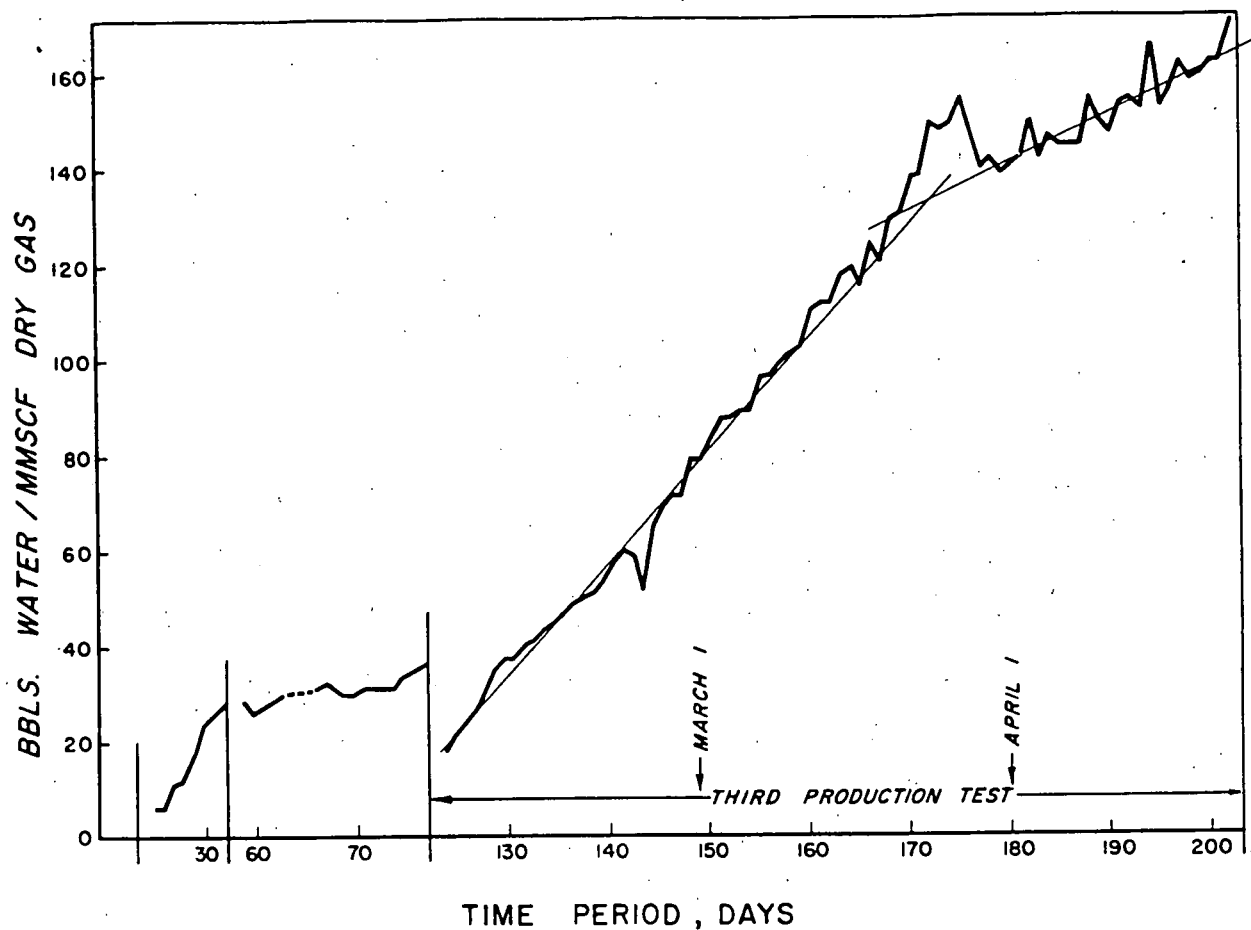


FIGURE 10. PROJECT RULISON DAILY WATER PRODUCTION

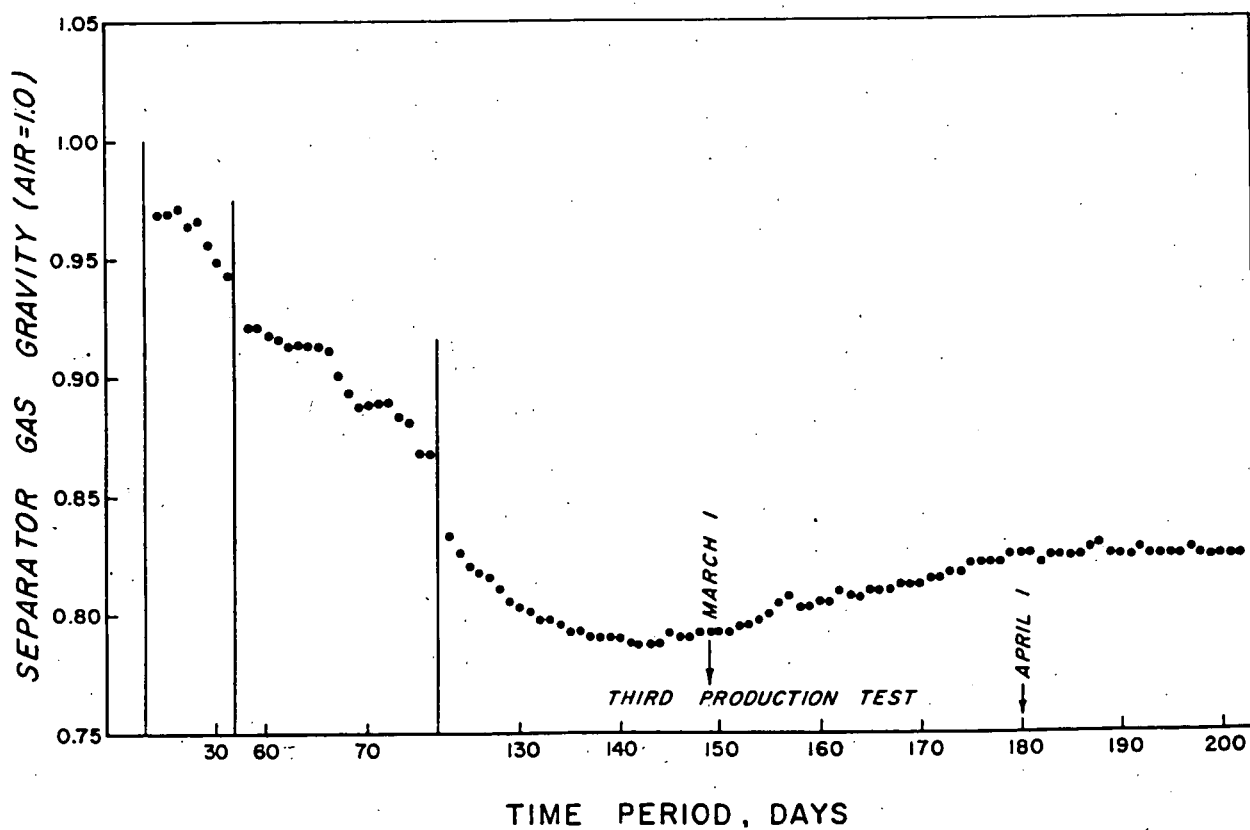


FIGURE 11. PROJECT RULISON SEPARATOR GAS GRAVITY

### c. Analysis of Well Performance

LLL made an analysis of the well performance by fitting a simple model of the chimney, gas sands, and explosively created fracturing to the two experimentally measured variables, flow rate and chimney pressure. The gas flow calculations for various trial models were made by a finite-difference solution to the nonlinear partial differential equation for radial Darcy flow. The model consisted of a central zone representing the chimney surrounded by a number of concentric zones representing the formation. The effect of explosive fracturing was simulated by increasing the permeability in the zones near the central zone; this increased-permeability region was represented by a 33-fold increase over the undisturbed formation permeability extending from the chimney wall out to a radial distance of 2.75 chimney radii.

These calculations were repeated until the calculated and measured pressures were in good agreement. The parameters that were varied during modeling that gave the best fit are given in the caption to Figure 12.

The use of these parameters to calculate the 20-year cumulative production of Rulison leads to a result of 1.8 Bcf. Essentially, the same result is obtained by CER. DeGolyer and McNaughton calculate a higher figure, 4.5 Bcf, primarily because they assumed a higher formation permeability and a time-varying water barrier in the fractured region. Additional experimental data would help to resolve the issue. Nonetheless, some prediction confidence results from these independent calculations.

#### 2.3.2 Postshot Gas Analysis

Gas from the R-E was sampled and analyzed several times by LLL at the request of LASL, CER, and NV. The first samples were taken January 9, 1969, before postshot production testing. The most recent was April 21, 1971, when the well was being blown down to permit access to the firing cable for an electrical length measurement. All of these samples contained less than 20 percent chimney gas. The clay collected on filters during the blowdown was found to contain only naturally occurring radionuclides.

Twenty-three samples of gas were analyzed during the calibration flaring and production testing of the R-E well. The

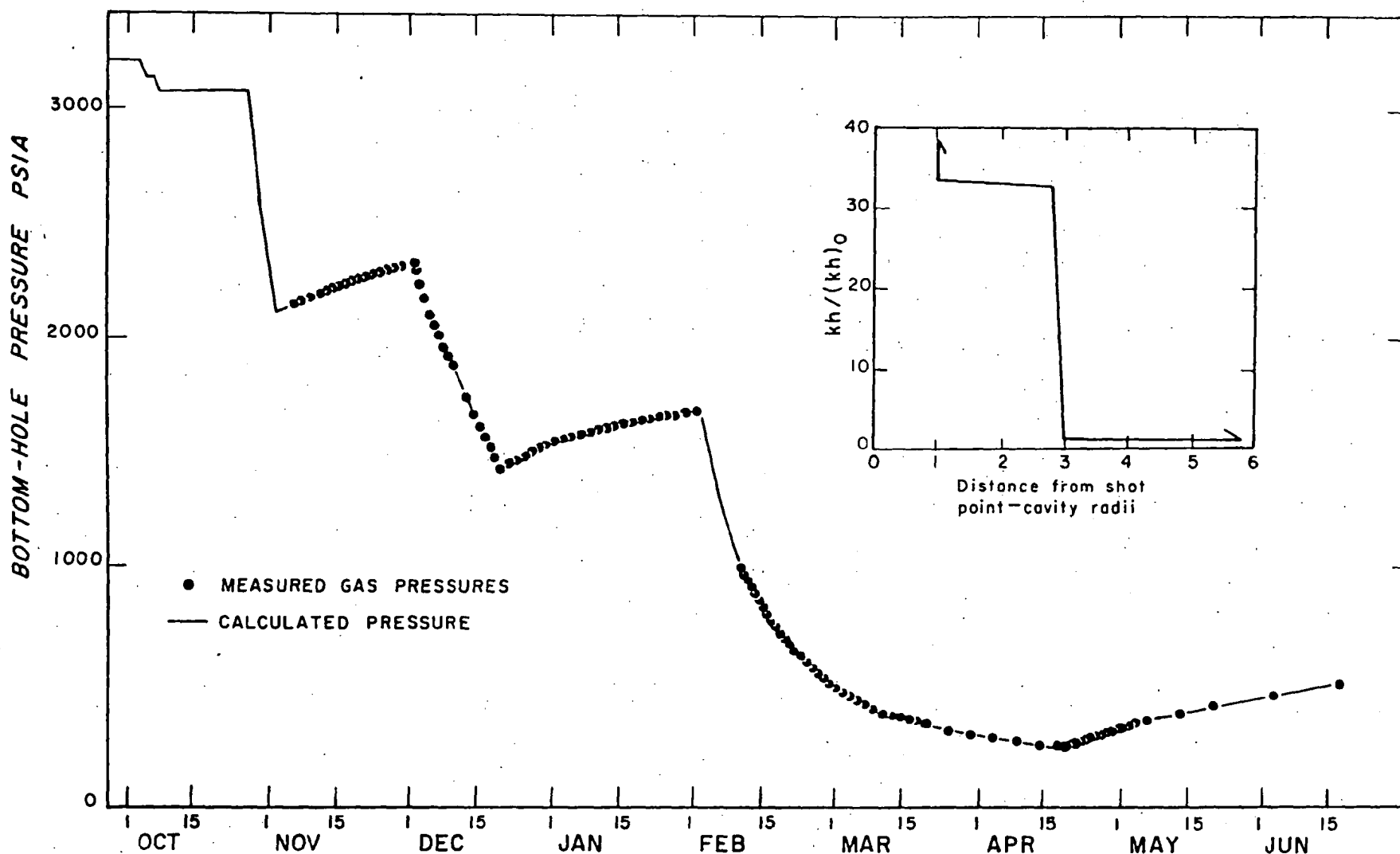


FIGURE 12. Gas flow from the Rulison experiment. The data covers the period from the time of the shot (September 1969) to June 15, 1971. The formation pressure is 3200 psia. The parameters assumed were:  $\phi h$  (porosity  $\times$  height) = 3.0 ft, the permeability  $\times$  height of the undisturbed formation  $[(kh)_0$ , where  $k$  is the permeability and  $h$  is the height] = 680  $\mu$ d-ft, and the postshot variation in  $kh$  as a function of distance from the shot point is shown in the inset graph. The cavity radius is 76 ft.

results cover the testing period from August 1, 1970, through April 23, 1971, when 426 MMCF of gas were flared. The combined effects of production and dilution of the initial chimney gases resulted in a reduction in the radionuclide concentrations present in the produced gas by about a factor of 50. The most significant radionuclide, tritium, decreased from 176 to 3.7 picocuries/milliliter (pCi/ml) of produced gas, while krypton-85 changed from 150 to 2.9 pCi/ml. Throughout the testing period, the distribution of tritium among the gases was approximately 81 percent in methane gas, 11 percent in hydrogen, 6 percent in ethane, and 1 percent in propane. The chemical composition of the produced gas also changed significantly during production. Carbon dioxide concentration dropped from 48 percent to 22 percent, and that of hydrogen from 15.7 percent to 1 percent. Concentrations of the components of formation gas increased through the test period by about a factor of 2. The methane concentration went from 32.8 percent to 71.6 percent, that of ethane from 1.7 percent to 3.6 percent, and that of propane from 0.3 percent to 1 percent.

The anomalous behavior of carbon dioxide is due to late-time introduction of this material from at least two sources. One of these, containing carbon-14 and accounting for a 15 percent increase in the total carbon dioxide available, may be evidence for the release of gas dissolved in chimney water. The second source released carbon dioxide which was free of carbon-14 and accounted for an 8 percent increase in total carbon dioxide in the chimney. This material could be the result of continued decomposition of carbonate minerals. A similar ebullition effect, though to a considerably lesser extent, is seen in the behavior of hydrogen. The specific activity of hydrogen gas is constant throughout the test, and is consistent with the maintenance of tritium exchange equilibrium between water and hydrogen gas. No other tritiated species in tritium exchange reactions were observed. Based upon an assumed total quantity (1,100 curies) of krypton-85 in the preproduction chimney gas and the reasonably constant total gaseous tritium-to-krypton-85 ratio, we infer that a total of 1,300 curies of tritium was present in the chimney gas before production. This is 13 percent of the total of 1 gram of this material which was predicted to be present following the detonation. The remaining 87 percent is presumed to be bound in nonvolatile compounds, water, and solidified melt.

The total gas volume calculated assuming a total of 1,100 curies of krypton-85 mixed uniformly with the chimney gases, was  $7.0 \times 10^9$  liters. This volume of gas could be contained in spherical void of radius 78 feet at a pressure of 210 atmosphere and a temperature of 435°F.

On April 19, 1971, just prior to termination of gas production of the Rulison chimney, two downhole sample bottles were opened at the 8,200-foot depth in the R-EX well. Of the two, the bottle containing the least water gave 4.2 grams of water in 250 cubic centimeter of chimney gas. The implied relative humidity is 16.8 milligrams (mg) of water per milliliter (ml) (290 barrels/MMCF) and may be compared to saturation conditions for steam at the 400°F recorded of 7.5 mg/ml (135 barrels/MMCF). Evidently, liquid water was collected along with the gas, implying gas saturation conditions and the presence of condensed water in the lower portion of the well.

### 2.3.3 Gas Production Calculations

A model of the Rulison chimney and reservoir has been developed which calculationally reproduces the observed chimney pressure history during the flow tests and subsequent build-up periods. The important parameters of this model include a  $R_c$  of 76 feet, an effective fracture radius of  $2.8 R_c$ , a reservoir permeability-height of 0.7 millidarcy-foot and a porosity height of 3 feet.

Logs indicate that about 80 feet of net gas sands are intercepted by fractures. Thus, the reservoir permeability is calculated to be about 0.009 millidarcy.



## CHAPTER III

### EFFECTS EVALUATION

#### 3.1 BACKGROUND

An effects evaluation report was prepared for Project Rulison to assess the hazards associated with the detonation. (See NVO-43, Effects Evaluation for Project Rulison, dated June 1969.) In evaluating potential hazards associated with a project such as Rulison, the following philosophy was followed: "A nuclear explosive can be detonated safely when it is ascertained that the detonation can be accomplished without injury to people either directly or indirectly, and without unacceptable damage to the ecological system and natural and man-made structures."

The Effects Evaluation Report was prepared by an Effects Scientist from LASL and an Effects Officer from NV. The report utilized prediction, evaluation, and program descriptions contributed by the Environmental Research Corporation (ERC), John A. Blume & Associates Research Division (JAB), USGS, USBM, Battelle Memorial Institute (BMI), NOAA/Earth Sciences Laboratory (ESL), NOAA/ARL, EPA/NERC, and Teledyne Isotopes (Isotopes).

#### 3.2 GROUND MOTION

##### 3.2.1 Predictions

Ground motion predictions were provided by ERC. NOAA/ESL instrumented for ground motion. Measured results and prediction curves are depicted in Figures 13 through 18.

##### 3.2.2 Conclusions

The primary conclusions to be drawn from the measured data are:

- a. The level of the peak vector velocities and displacements observed from Rulison in general agreed with predicted levels. However, the peak vector accelerations were slightly higher than predicted. The observed peak vector accelerations and velocities significantly exceed the level expected from a normally buried 40-kt contained device detonated on the Nevada Test Site (NTS).
- b. The pseudo relative velocity spectra calculated from Rulison ground motions agree well with the spectra predicted on the basis of scaling theory, accounting

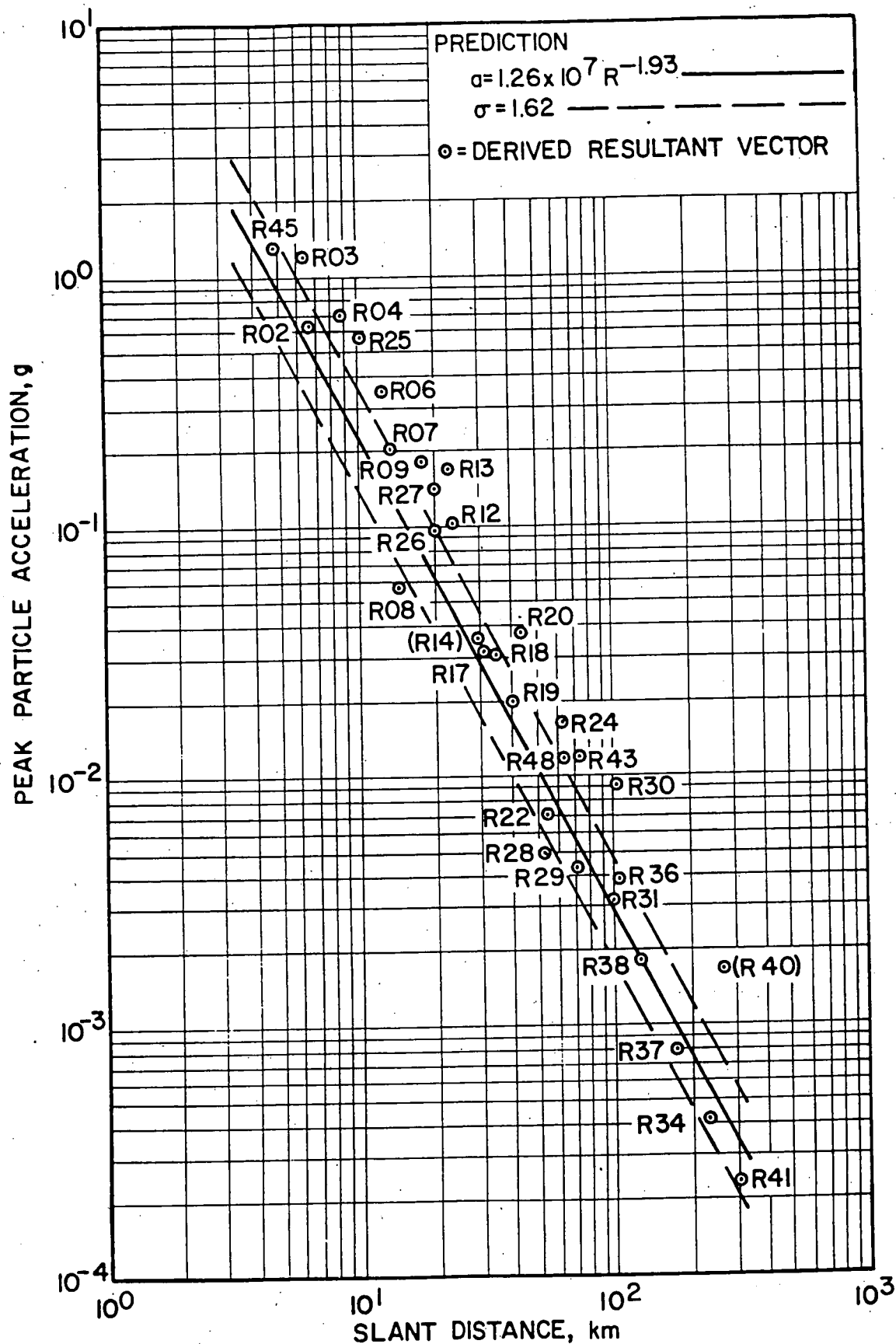


FIGURE 13. PROJECT RULISON PEAK SURFACE PARTICLE ACCELERATION  
 RECORDED AT STATIONS ON HARD ROCK

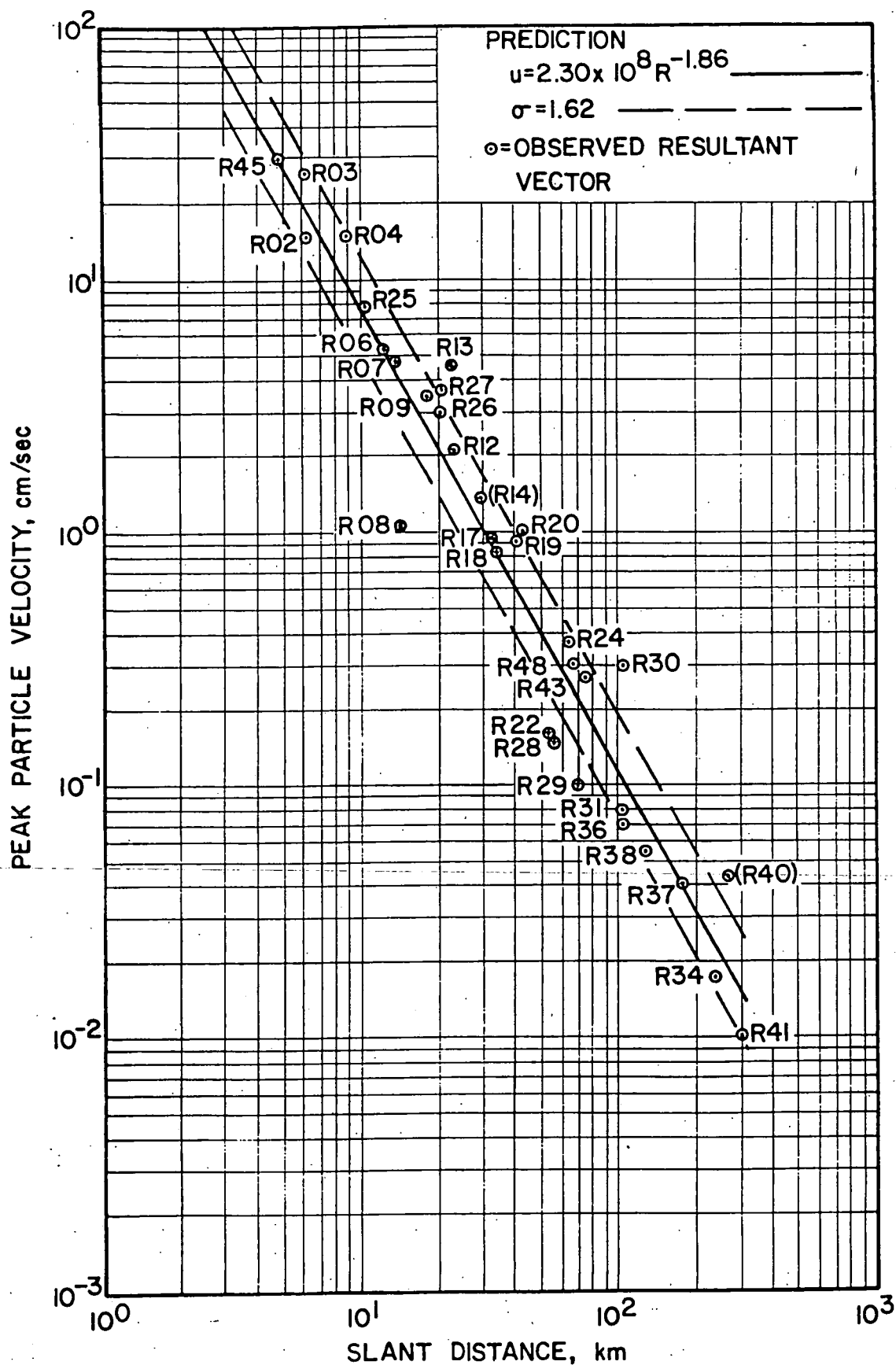


FIGURE 14. PROJECT RULISON PEAK SURFACE PARTICLE DISPLACEMENT RECORDED AT STATIONS ON HARD ROCK

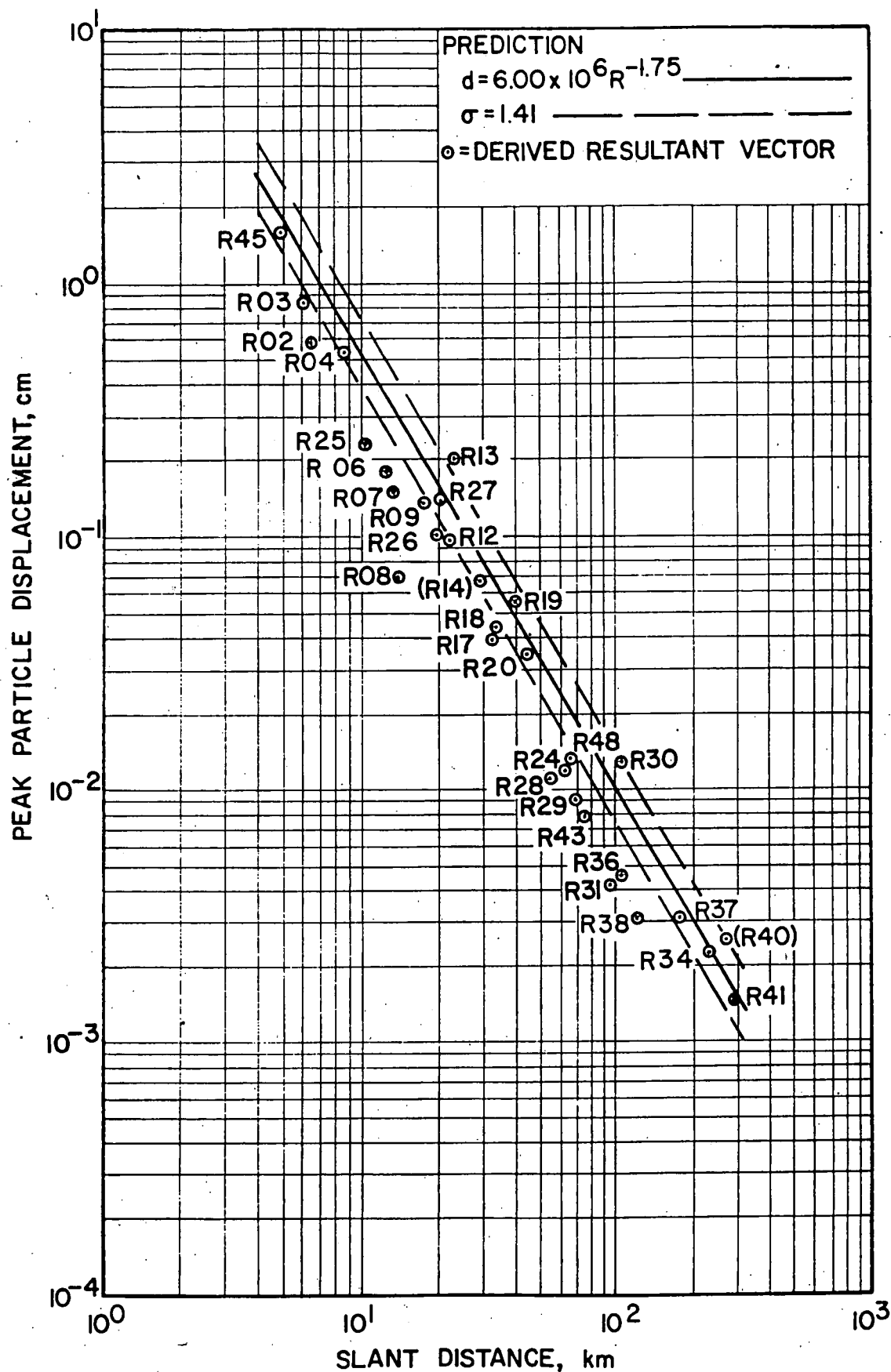


FIGURE 15. PROJECT RULISON PEAK SURFACE PARTICLE VELOCITY  
 RECORDED AT STATIONS ON HARD ROCK

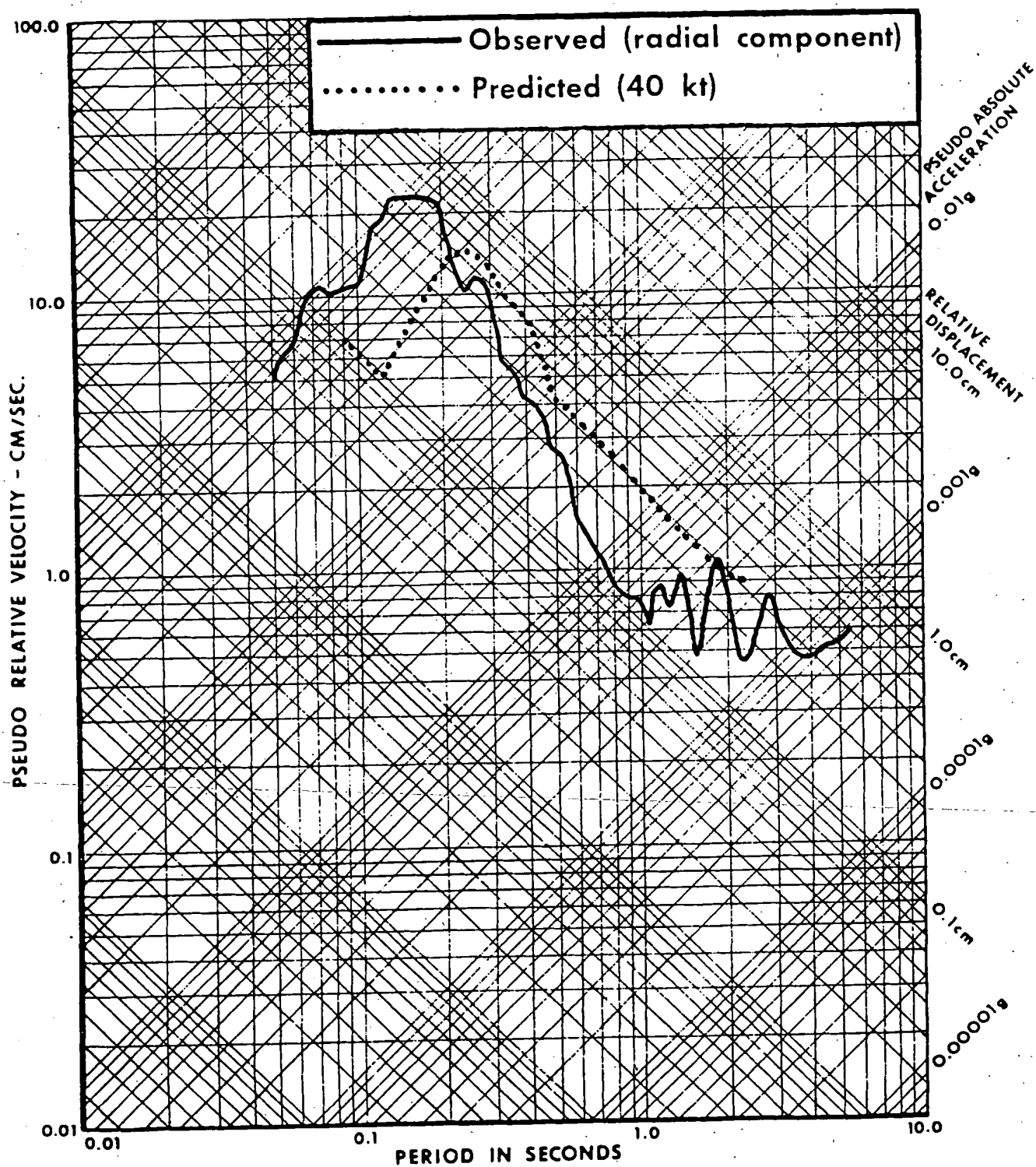


FIGURE 16. COMPARISON OF OBSERVED AND PREDICTED 5% PSEUDO RELATIVE VELOCITY SPECTRA AT GRAND VALLEY, 10.6 KM FROM PROJECT RULISON

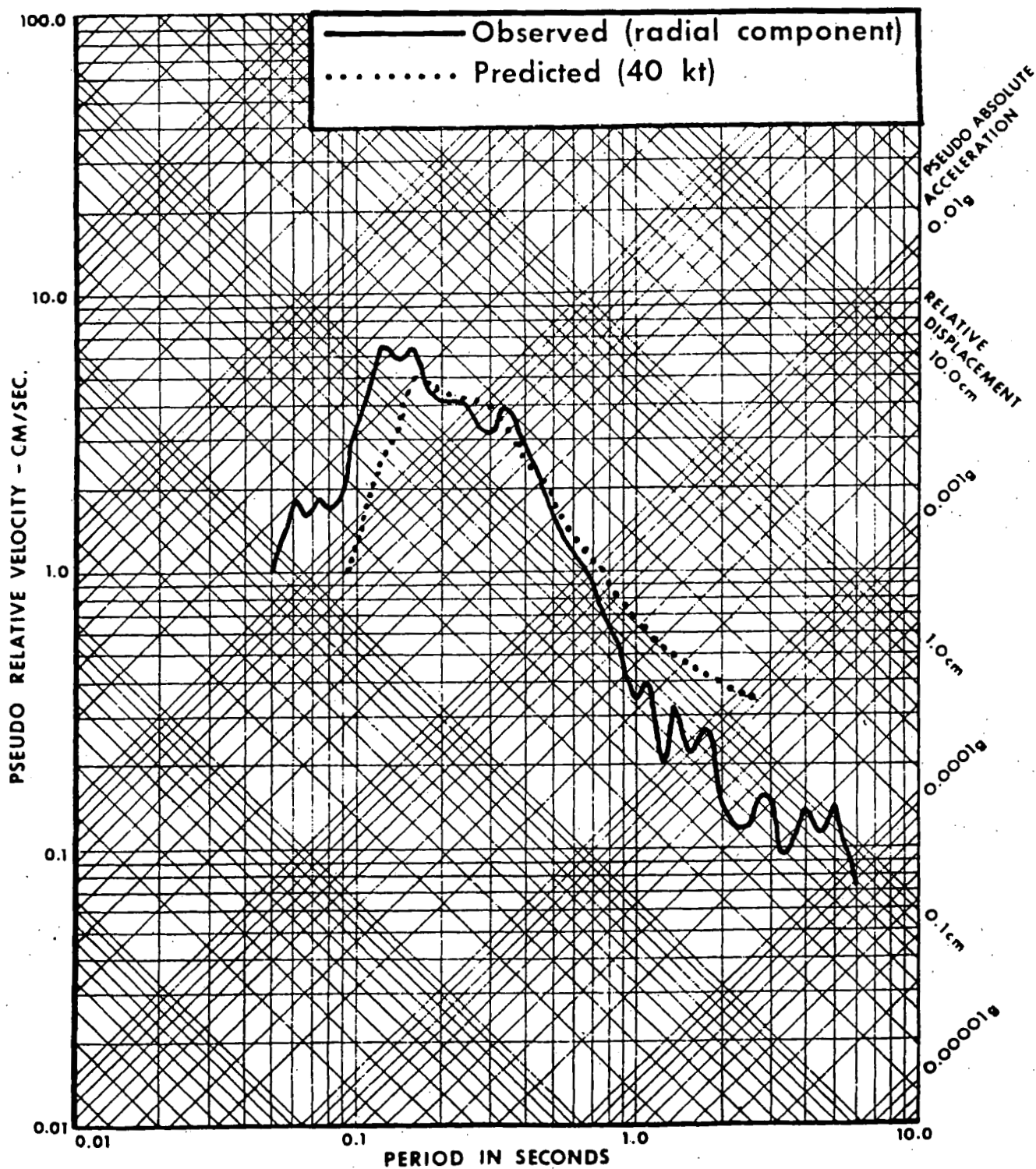


FIGURE 17. COMPARISON OF OBSERVED AND PREDICTED 5% PSEUDO RELATIVE VELOCITY SPECTRA AT THE RIFLE METHODIST CHURCH, 20.2 KM FROM PROJECT RULISON

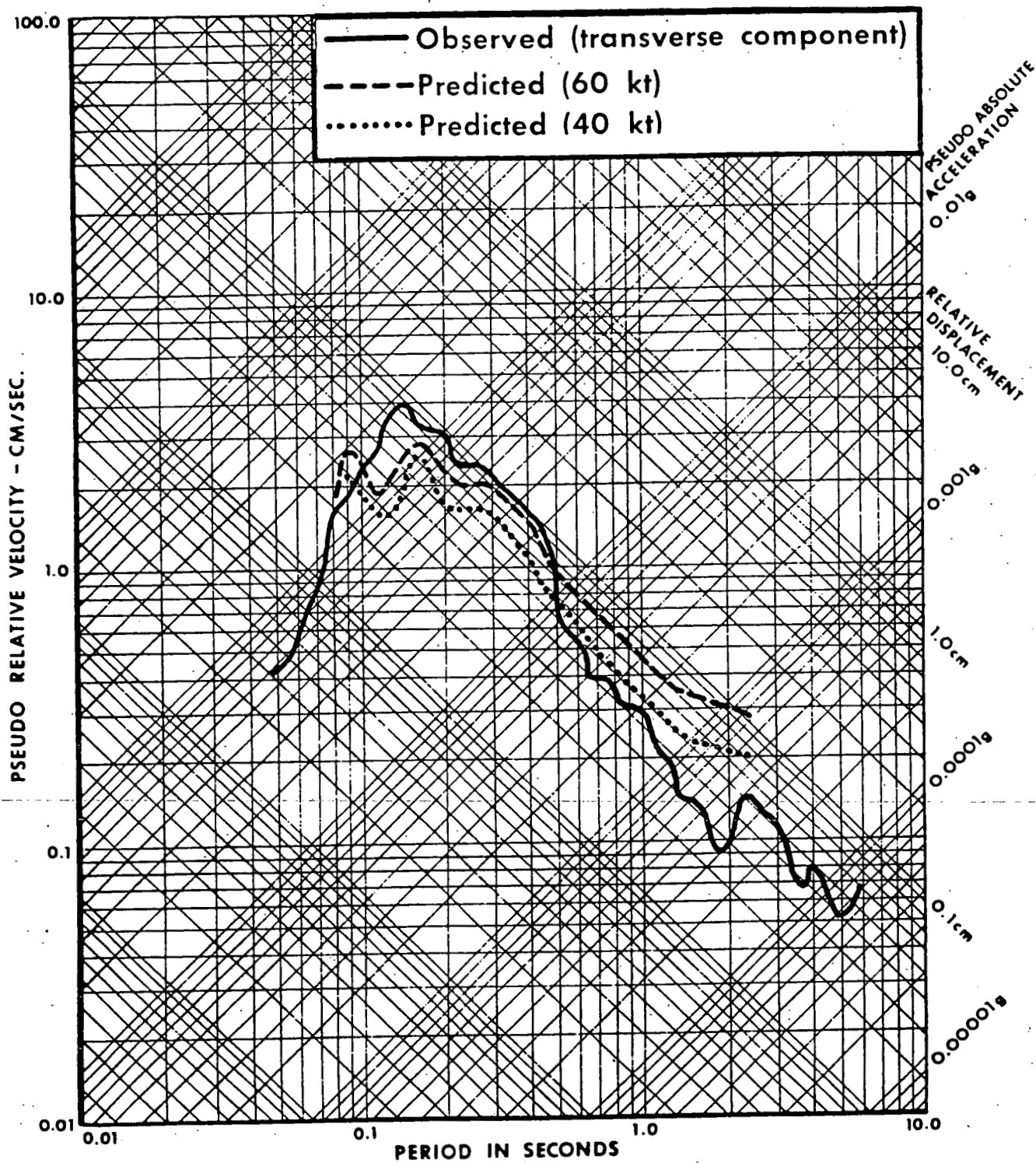


FIGURE 18. COMPARISON OF OBSERVED AND PREDICTED 5% PSEUDO RELATIVE VELOCITY SPECTRA AT THE HARVEY GAP DAM, 32.4 KM FROM PROJECT RULISON

for differences in yield and device depth of burial. The peak spectral response exhibits a higher level and occurs at shorter periods (0.1--0.4 seconds) than that of the spectral response expected from a normally buried 40-kt contained device detonated on NTS.

### 3.3 STRUCTURAL RESPONSE

JAB prepared estimates of the response of structures to the ground motion predicted by ERC. Evaluation of available data indicates that the JAB preshot predictions of damage were valid. Most of the damage occurred at locations close to ground zero and involved either plaster cracking or chimney damage. The types of damage complaints received are indicated in Table 1 and the number of damage complaints versus distance is indicated in Figure 19. Chapter XV gives additional data on private property damage complaints.

Of particular concern was possible damage to the Harvey Gap and Battlement Mesa Dams, 32.4 and 4.9 km distance from the detonation point, respectively. The reservoir behind Harvey Gap Dam contained 1,650 acre feet of water at shot time, approximately 30 percent of full capacity. The detailed evaluation of the stability of the dam had indicated there should be no problem if the water level was at least 15 feet below crest elevation. No damage was observed at Harvey Gap Dam which received peak horizontal acceleration of 0.035 gravity (g). The Battlement Mesa Dams received over 1.0 g ground motion with no resulting damage being observed.

Some rebuilding or removing of chimneys at close-in locations was accomplished prior to the detonation. The results indicated that the care taken during the preshot activity was well advised. At these locations, none of the remaining chimneys fell, although some loose bricks on the tops of small chimneys did fall as was predicted.

### 3.4 MINE AND WELL SURVEY

#### 3.4.1 Mine Survey

An evaluation program of mines and oil and gas wells was carried out by USBM. It was designed to identify, evaluate, and eliminate or control all potential hazards to mining and petroleum operations in the general project area and to document the effects of the nuclear explosion on such operations (Figure 20).

The postshot inspection indicated that structural damage occurred at only two mines; the Cameo and Red Canyon Coal Mines, 27 and 32 miles, respectively, from the R-E. (See Figure 20.) The damage at Cameo could reasonably be attributed to the Rulison detonation, while the relatively



TABLE 1.--Type Of Damage Complaint

Location	Chimney	Interior Plaster	Windows	Cisterns	Wells	Fireplaces	Foundations	Masonry Walls	Other Ext. Walls	Utility Lines	Roofs	Earth Slides	Television Sets	Household Items	Other Items
Grand Valley	77	65	14	13	4	5	17	15	13	4	4	3	2	4	37
Rifle	27	53	11	--	2	6	29	23	10	3	3	1	--	1	22
Collbran	4	13	2	2	2	3	12	2	--	1	--	1	1	2	9
>20 Kilometer (km)	1	20	1	4	1	2	8	12	2	1	1	2	2	1	16
Total	109	151	28	19	9	16	66	52	25	9	8	7	5	8	84

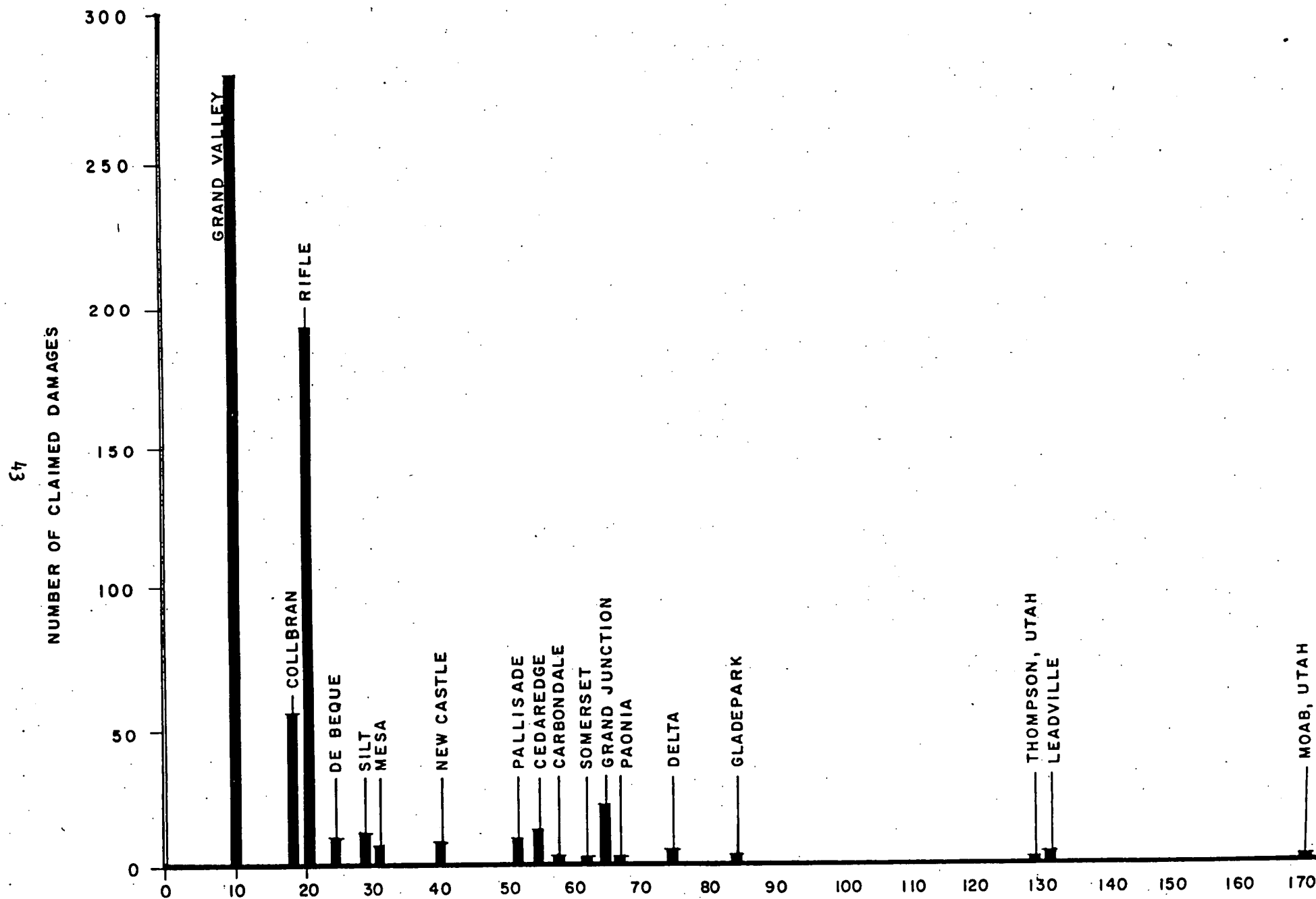


FIGURE 19. PROJECT RULISON DAMAGE CLAIMS VS DISTANCE

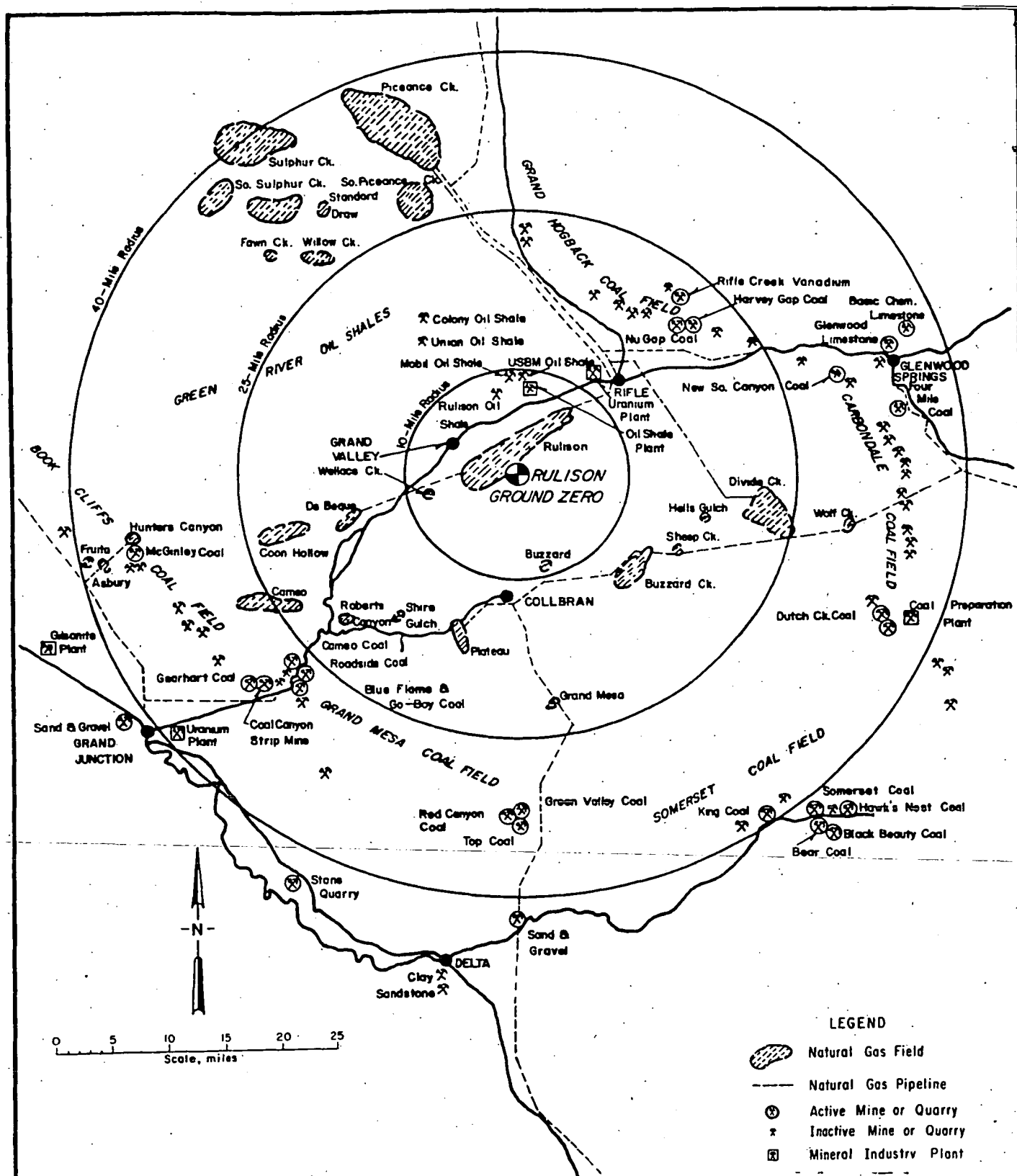


FIGURE 20. MINERAL INDUSTRY DEVELOPMENT IN VICINITY OF PROJECT RULISON

minor damage at Red Canyon might or might not have been. No significant damage attributable to Rulison was observed at any of the other nearby mines inspected, nor was damage reported by the operators of the fringe area mines. However, small rock slides, isolated rockfalls, and minor slumping of rock fills were observed or reported along mine access roads, especially on those roads along the steeper, less stable canyon slopes. Mines closer to SGZ received less damage than predicted. Actual mine damage was experienced at observed peak ground motions of only 0.04 to 0.07 g.

#### 3.4.2 Well Survey

At the request of the Effects Evaluation Division, of the AEC/NV, the USBM inventoried gas wells and associated facilities within a 10-mile radius of SGZ. All wells and facilities within five miles of SGZ were examined and photographed in detail, both preshot and postshot.

The well safety survey indicates that neither surface nor subsurface damage occurred to any field gas well or related facility. At these distances, ground motion values were lower than those at which damage could be anticipated.

No surface damage was observed at R-E and R-EX wells. Estimated surface motion at SGZ and motion at the nearest producing well were equal to or less than those at Gasbuggy and at its nearest producing well. Thus, no new damage criteria have been defined. Gasbuggy data shows that subsurface damage did not occur beyond distances where ground motion was in the range 25 to 250 g and 400 to 5,000 centimeters per second.

### 3.5 GEOLOGY AND HYDROLOGY

#### 3.5.1 Geology

Geological background investigations of the Rulison area by USGS showed a uniformly simple structural picture of the project area. The Rulison field structure is part of the Piceance Creek Basin, with its relative position in the Basin shown in Figure 21. The field is on the southwest limb of the Basin structure (see Figure 22). Upper Cretaceous beds in this area dip towards the northeast at approximately 150 feet per mile. The overlying tertiary age beds lie relatively flat.

Details of the Battlement Mesa geology were reviewed with representatives of USGS who contributed maps and reports on

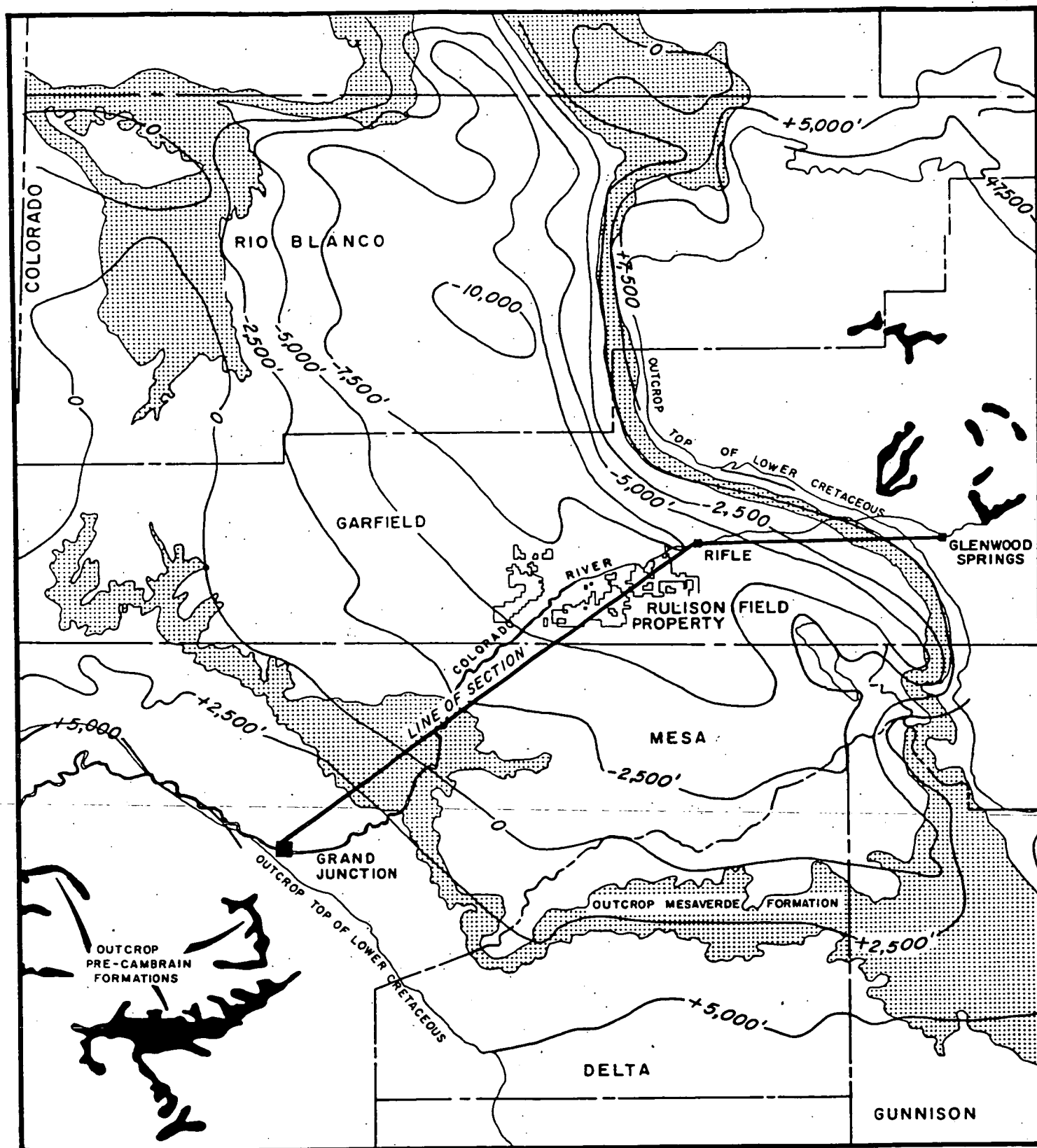


FIGURE 21. PICEANCE CREEK BASIN-REGIONAL MAP AND STRUCTURAL INTERPRETATION

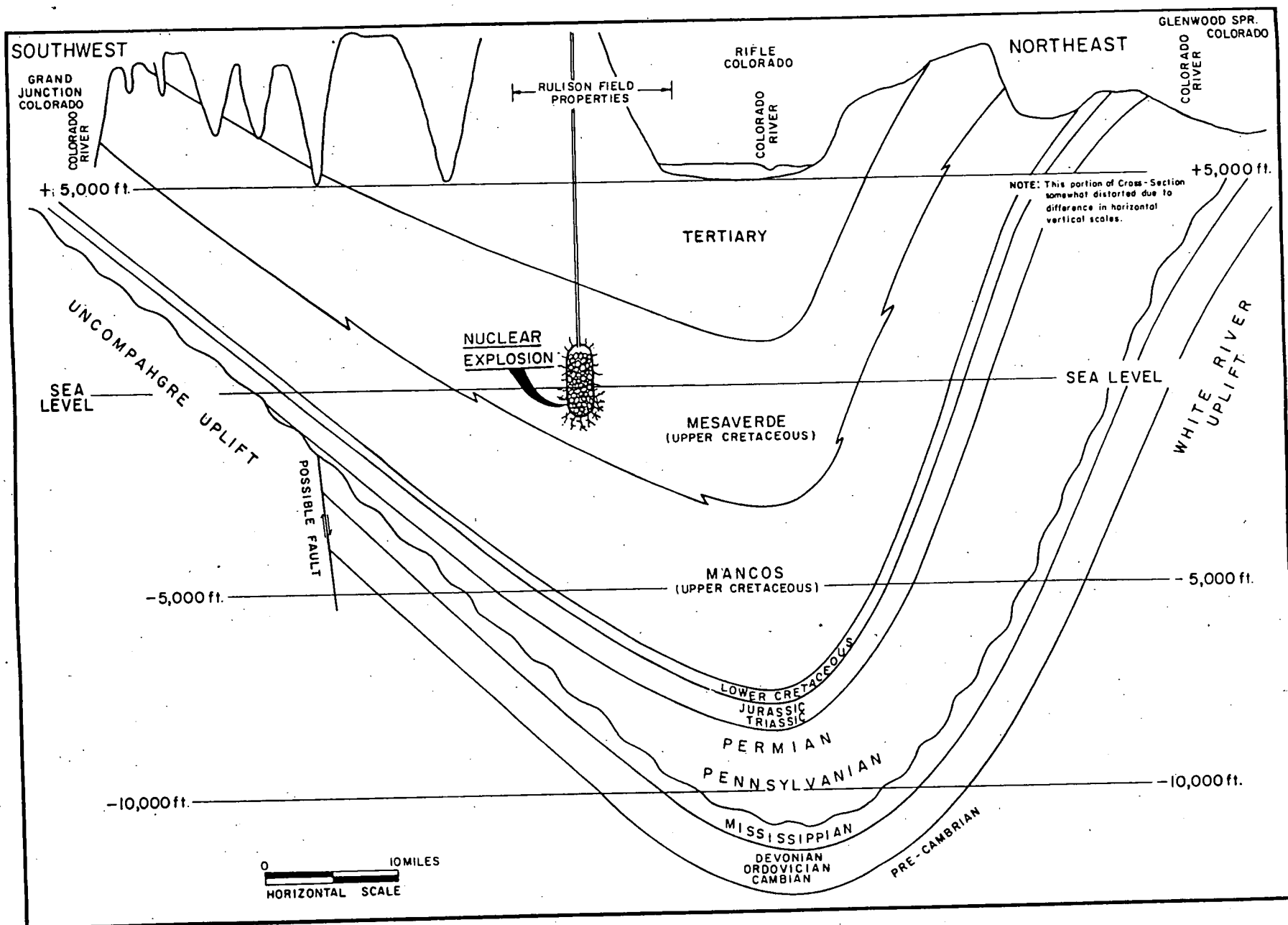


FIGURE 22. PICEANCE CREEK BASIN SCHEMATIC CROSS SECTION

the area.<sup>1</sup> & <sup>2</sup> In addition, a surface geological study of a small portion of the area surrounding the site was made by Austral/CER and LLL geologists.

Rocks ranging in age from recent alluvial fill to Precambrian "basement" are present in the Rulison area. The sequence of rocks present and their relation to the general stratigraphy of the Piceance Creek Basin are shown in Figure 23.

The "bedrock" at the Project Rulison site is the lower Green River Formation. The base of the Green River occurs at a subsurface depth of approximately 1,700 feet in the R-EX well. Relatively impermeable Wasatch and Fort Union shales and siltstones were encountered below the Green River in the interval from approximately 1,700 feet to 6,134 feet in the R-EX well. The basal Tertiary Ohio Creek Formation occurs between the Fort Union and the Mesaverde, encountered at 6,188 feet. The depositional setting for the Mesaverde in the Rulison field resulted in the formation of lenticular sandstones which, from available data, have limited areal extent. The lenticularity of the Mesaverde sandstone reservoirs is the cause of gas entrapment in the Rulison field.

### 3.5.2 Hydrology

The Colorado River and its larger tributaries in the area flow on alluvial deposits. Limited coring by the USGS Groundwater Branch shows that the suballuvial floors of the valleys are approximately 80 to 100 feet below the flowing stream levels.

Most of the precipitation is carried into the Colorado River by small streams or underflows in the alluvial fill or terraces. A few springs are present where the underflow in the alluvium is deflected to the surface by relatively impermeable bedrock.

USGS participated in the hydrologic testing of the exploratory hole, thereby defining the hydrologic system overlying the detonation point. All zones that produced water during drilling, or in which geophysical logs suggested the possibility of water, were evaluated. USGS concluded that little or no mobile water occurs in the Ohio Creek conglomerate and the Mesaverde Group, which are the stratigraphic units most likely to yield water to the hole.

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<sup>1</sup>W. E. Yeend, "Quaternary Geology of the Grand-Battlement Mesa Area, Colorado," USGS Open File Report, 1967.

<sup>2</sup>J. R. Donnell, "Rulison Area Geological Maps," USGS Open File, 1968.

SYSTEM AND PERIOD		FORMATIONS	GENERAL LITHOLOGY	APPROX. THICKNESS
QUATERNARY		"Recent"	Low terrace, floodplane, and alluvial deposits	100'
		"Pleistocene"	Terrace and fan sand and gravel, pediment gravel, colluvium, mudflow, and solifluction deposits	200'
TERTIARY		(?)	Basalt flows underlain by variegated claystones and gravel	1,000'
		Green River	Oil shales, marlstones, and sandstones (dark color)	2,100'
		Wasatch	Bright colored clays and shale with minor sandstone	5,000'
		Fort Union	Brown-gray shale and coal	1,000'
		Ohio Creek	Sandstone and conglomerate	50'
CRETACEOUS	UPPER	MESAVERDE		
		Lewis-Lance Equiv.	Shale - sandstone	2,500'
		Williams Fork	Shale	
		Isle	Shale - sandstone	
	LOWER	Mancos	Gray shale	1,700'
		Naturita	Shale - sandstone	600'
		Dakota Cedar Mt.	Sandstone	200'
JURASSIC		Morrison	Variegated shale and sandstone with interbedded tuff and ash	800'
TRIASSIC		State Bridge	Red arkosic sandstone	600'
		Schoolhouse	Sandstone	60'
PERMIAN		Minturn	Continental red beds interbedded with white Weber type sandstone	1,000'
		Maroon	Buff-red sandstone	
PENNSYLVANIA		Eagle Valley	Evaporites (chiefly anhydrite)	2,800'
		Belden	Gray to black shale with basal conglomerate	
CAMBRIAN THROUGH MISSISSIPPIAN		Madison, etc.	Limestone, dolomite and quartzite	~700'
PRE-CAMBRIAN			"Basement" metamorphics and plutonics	

FIGURE 23. RULISON AREA STRATIGRAPHY



### 3.6 BIOENVIRONMENTAL EFFECTS

A preshot bioenvironmental survey of the area around the Rulison site was made early in 1969 by BMI. The objectives were to characterize the ecological setting of the project site and to identify any potential adverse consequences of the project for which preventive or remedial action might be required.

The only significant bioenvironmental hazard identified during the preshot survey was the possible danger of pollution of Battlement Creek by drilling wastes or other contaminants resulting from drill site operations. Sump ponds used in drilling the R-EX and the R-E were located very close to the channel of the East Fork of Battlement Creek. A sump failure that occurred during the drilling of the R-EX (December 1967) killed fish in the stream below the site and temporarily contaminated the domestic and stock water supplies of some of the Morrisania Mesa residents. The preshot bioenvironmental survey report recommended that adequate precautions be taken to prevent any further pollution of the Battlement Creek watershed during the final site preparation and detonation phase. A water sampling plan for evaluating effectiveness of such precautionary measures was also outlined.

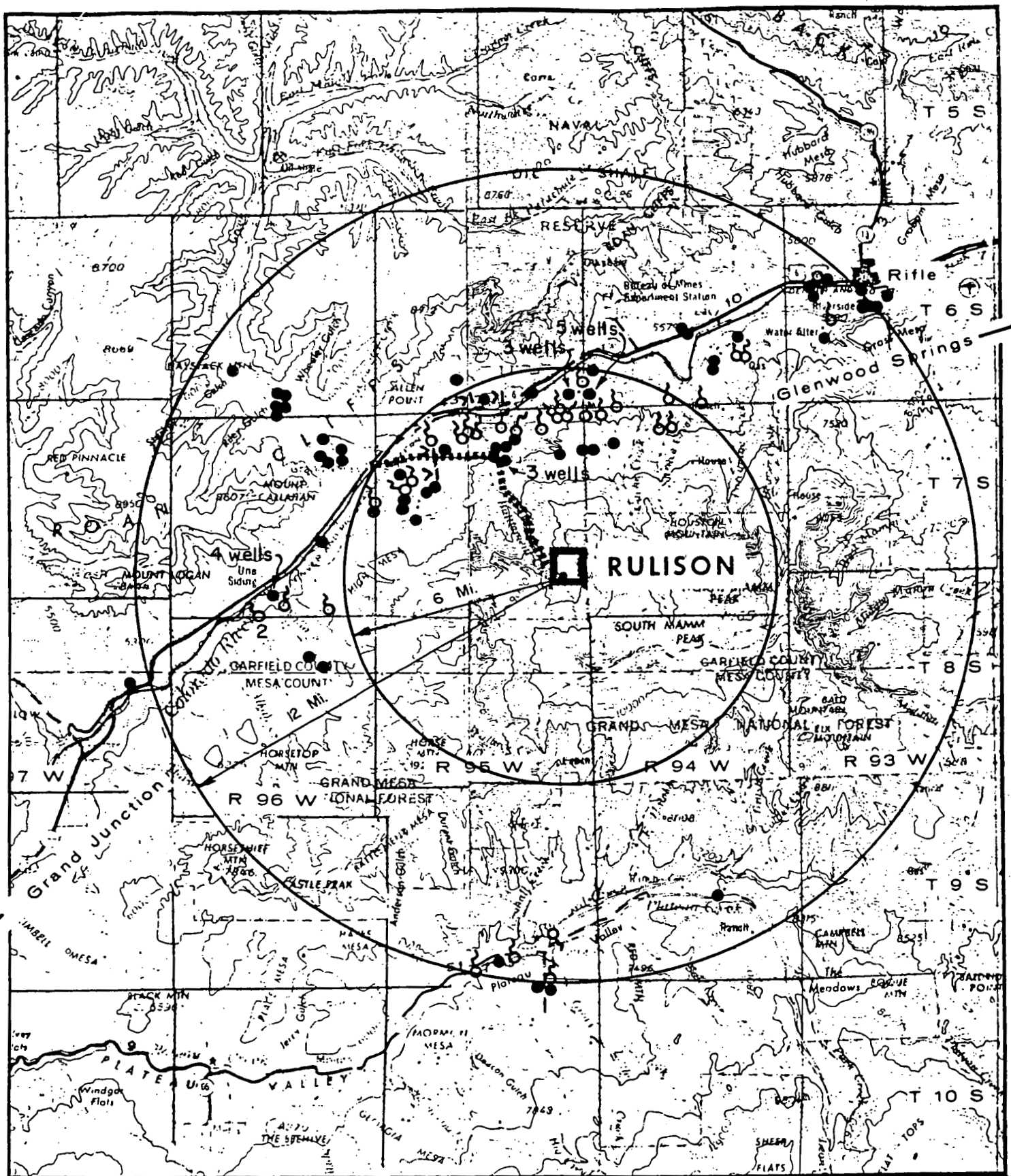
Prior to the detonation, the sump pits remaining from the drilling of the emplacement hole, with one exception, were cleaned and filled with earth.

Results of a pre- and postshot stream water sampling program carried out by the Colorado Department of Health indicated that the precautions taken were successful. Springs and wells in the vicinity of the Rulison site were sampled by USGS (Figure 24). Corresponding samples were taken after the shots. While some increase in spring flow and well flow in Battlement Creek was observed immediately following the shot, the flow in all cases returned to preshot levels within a short time. No difficulties were observed in wells or springs after the shot.

Since the Rulison shot was designed for complete containment of radioactivity, it was not necessary for the preshot survey to concentrate on potential ecological problems due to release of radioactivity to the environment. However, in preparation for the postshot drillback and production testing phase, predictive models were utilized for estimating potential internal radiation doses to humans via environmental pathways.

### 3.7 AFTERSHOCK STUDIES

USGS, operating under agency funding and not directly participating in the Rulison program, utilized five seismograph stations within



SCALE 1:250,000

- Well
- Spring
- ✕ Indicates more than one spring at location

FIGURE 24. WATER WELLS AND SPRINGS IN THE VICINITY OF PROJECT RULISON

15 km of SGZ to monitor seismic activity.<sup>3</sup> These stations were operated from 72 hours previous to detonation and until 18 hours after the detonation. No earthquakes were recorded in the preshot period. Upon detonation, 16 aftershocks were recorded within the first 43 minutes. These aftershocks, all of which had a Richter magnitude of less than 1, were located within 1 km of the explosion.

During September 1969, NOAA/ESL operated five continuously recording seismic stations located at the Rulison Observer Area and at Rifle, Collbran, Eagle, and Meeker, Colorado. The stations were capable of identifying and locating all earthquakes of magnitude 1.0 or larger, originating within 10 miles of Rulison. Instrument gains (sensitivity) were changed at H-8 hours in order to document the ground motion produced by Rulison. All stations had been returned to the preshot levels by H+2 hours in order to document after shocks. There were no seismic events detected within 100 km of Rulison in the preshot period from September 3, 1969, to September 10, 1969. Fourteen seismic events within 100 km of Rulison were detected between September 10, 1969, and September 30, 1969. Nine of these were large enough to be adequately recorded for the determination of Richter magnitude. The largest had an approximate Richter magnitude of 2.2 and was located near Snowmass Mountain, about 74 km southeast of the site. The number of natural seismic disturbances located within 100 km of Rulison in September is interpreted by the NOAA/ESL as being due to the increased detection capabilities rather than to an increase in the rate of activity.

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<sup>3</sup>Seismic Monitoring of the Rulison Underground Nuclear Explosion near Rifle, Colorado, on September 10, 1969, by R. M. Hamilton, B. E. Smith, and J. H. Healy, USGS Open File Report 1970.

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## CHAPTER IV

### PROJECT EXECUTION

#### 4.1 GENERAL

Project Rulison was executed at 3 p.m., MDT, on September 10, 1969, after having been delayed from September 4, 1969, due to unfavorable weather conditions. All available data indicated that the explosive yielded  $43 \pm 8$  kt of energy. No radioactivity was detected on the surface either on- or offsite as a result of the detonation. No injury or serious damage to property resulted from the detonation. All operational plans were executed on schedule and in a satisfactory manner. A minor communication failure occurred immediately postshot which temporarily put the main net communications repeater off the air for about 20 minutes. In the interim, a substitute airborne repeater was used satisfactorily.

#### 4.2 THE OPERATIONS AND SAFETY PLAN

An Operations and Safety Plan for Project Rulison was developed based on conclusions identified in the Effects Evaluation Report (NVO-43) for Project Rulison and on appropriate meteorological conditions that were predicted to prevail during shot time. Development of these plans included consideration of both human (transient and stable) and milk cow populations determined from surveys of the area.

Considering wind direction and velocity, the firing sector fell between 90 degrees and approximately 140 degrees using SGZ as the point of origin.

Three p.m. was selected as the optimum firing time after considering: 1) the number of daylight hours available to implement the pre- and postshot evacuation plans, 2) the number of daylight hours required to respond in case of an emergency, 3) the school bus schedule and the frequency of highway traffic, 4) the traffic frequency of the Denver & Rio Grande Western Railroad, and 5) the plant and underground mine workers' schedules.

#### 4.3 AREA CONTROL

The area from SGZ out to a radius of five miles was closed to anyone except official participants. Deputies of the Garfield County Sheriff's Department, Wackenhut Services, Inc. (WSI), and EPA/NERC personnel controlled and evacuated the area. Area residents were asked to evacuate their homes, and they were told that all utilities would be turned off during their absence. Except for three families who elected not to leave their homes and for some half-dozen protestors hidden in the mountains, the operation went smoothly.

The area within the 5- to 9-mile radii from SGZ was classed as a potentially hazardous zone for ground motion reasons. Therefore, residents were asked to be out and away from structures for a distance of at least two building heights. Area control and evacuation were handled by EPA/NERC and Garfield County Sheriff's personnel. No difficulties were encountered in executing this portion of the Operations Plan.

Based on potential rock slide hazards identified in the NVO-43 report, about 25 portions of various federal, state, and county roads were blocked during shot time. Those agencies involved in controlling these blocks included the Colorado State Patrol, the Garfield County and Mesa County Sheriff's Departments, and the Mesa County Road Departments. Only minor rockfalls were experienced after the shot, and the roads and highways were opened immediately after being declared clear by controlling agencies. No complications were encountered in this program.

With the cooperation of railroad officials, nine sections of the Denver & Rio Grande Western Railroad track were controlled. No rail traffic passed through these potential slide areas during shot time. Several miles northeast of DeBeque, a rockfall resulted in a couple of hours delay in returning rail traffic to normal. This program was carried out effectively and on schedule.

A mine safety program, under the direct supervision of CER, involved the evacuation of approximately 23 underground mines during shot time. This program was also accomplished satisfactorily. (See Section 3.4.)

#### 4.4 AIR OPERATIONS

Air support for the project was furnished by the U.S. Air Force, EPA, and EG&G, Inc. (EG&G). In addition, the Colorado Game, Fish and Parks Department's fixed-wing aircraft assisted in the D-day surveillance. Air space was controlled during shot time up to 15,000 feet within a 5-nautical-mile radius of SGZ through the cooperation of the Federal Aviation Agency's Denver Air Route Control Center.

All assigned missions were completed successfully although some modifications were required to tasks assigned to the two Air Force helicopters. A planned zero time air photo mission was canceled because additional surveillance tasks were assigned during D-day. A greater than anticipated number of surveillance missions were flown during the week prior to shot day due to intelligence reports of protestors camping in the mountains above SGZ. The 2 1/2 miles of arming and firing cables which ran from the CP to SGZ were under close surveillance.

#### 4.5 OPERATIONS COORDINATION CENTER

An Operations Coordination Center (OCC) was established at the CP on a 24-hour-per-day basis for several weeks prior to the detonation. This facility was the terminus for all operational communication links including low band net radio, closed circuit television (CCTV), telephone, and air-to-ground radio. During D-day, all control functions were reported to this center and recorded by time to assure that all scheduled safety and control measures were accomplished prior to detonation.

DONO and his Advisory Panel were kept constantly informed on D-day of status of control measures being performed, as well as being continually updated with weather data. It was from this center that DONO authorized the detonation.

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## CHAPTER V

### ENGINEERING AND LOGISTICS SUPPORT ACTIVITY

#### 5.1 DIVISION OF RESPONSIBILITY

Appendix A of Contract AT(26-1)-469 between Austral and the government established the division of responsibility between the government agencies, Austral, and the Program Manager (CER) for design, construction, and logistics support during Phase I, Phase II, and Phase III of the project.

By an AEC letter, dated March 10, 1970, Austral and CER agreed and accepted changes in the division of responsibility for Phase III, postshot investigations. These changes resulted in the AEC assuming total responsibility for the offsite safety program, including logistical support, during Phase III.

#### 5.2 GOVERNMENT SUPPORT CRITERIA

The forecast of requirements and the firm requirements for all government agencies and government contractors were provided the Program Manager in accordance with the division of responsibility. The Project Definition Plan (PNE-R-11) included a forecast of the construction and logistics support requirements. Minimal revisions were made in the requirements before the firm requirements for Phase II were finalized.

Because of the contractual changes in the division of responsibility for Phase III, additional support requirements and revisions to requirements were necessary. The Program Manager was furnished the revised requirements based upon the Phase III program for the postshot investigations and the radiological safety and weather surveillance designated in the Project Rulison Post-Shot Plans and Evaluations document (NVO-61). Construction and logistics support requirements for the offsite radiological safety programs were transmitted to REECO, which was authorized to provide the specified support for the AEC-funded programs.

#### 5.3 R-E

##### 5.3.1 Drilling the R-E

Austral's drilling contractor, Signal Drilling Company, spudded the emplacement hole on September 29, 1968, and reached the total depth of 8,701 on January 18, 1969. The drill rig was released on February 2, 1969. The hole was drilled with a low solid and low weight (9.4 pounds/gallon maximum) mud to obtain a maximum penetration rate.

The wellhead was equipped with one 16-inch Shaefer blowout preventer (BOP) and one 20-inch Hydril BOP testing at 1,200 pounds per square inch (see Figure 25). The formation interval in the vicinity of the explosive working point was cored (8,384.5 feet to 8,444.5 feet, ground level reference) to provide additional data for LASL's use and for industry's evaluations. The casing was cemented in three stages with an interval of mud from 1,850 feet to 6,130 feet (see Figure 26).

"Ruff-cote" casing was used in the interval from approximately 8,033 feet to 7,603 feet. An annular container was welded to the outside of the casing and centered on the working point, which was filled with boron carbide.

#### 5.3.2 Stemming the R-E

Stemming material for the emplacement was supplied from NTS production sources. The stemming material furnished was approximately 4,210 cubic feet of coarse material and 400 cubic feet of fine material. The material was sacked, palletized, and banded at the NTS and delivered to Austral/CER. All costs for production and handling were reimbursed by Austral.

The stemming material was emplaced in alternate, but unequal, lifts of coarse material and fine material with the fines being premixed with bentonite. The stemming operation required approximately 270 working hours.

### 5.4 CONSTRUCTION AND LOGISTICS SUPPORT

The division of responsibility was divided between Austral, CER, and the government as explained in Section 5.1.

#### 5.4.1 Phases I and II

During the drilling and testing of the R-EX, NV field representatives visited the site and attended meetings for the purpose of reviewing the casing and cementing program, the hydrologic testing program, and the gas testing program.

During the construction of the R-E, a NV representative, with the assistance of Fenix & Scisson (F&S) engineers, observed the logging, casing, and cementing operations. Austral carried on the work using the latest techniques and good oil field practices and procedures.

NV contributed several suggestions relative to AEC safety considerations. These suggestions included: 1) additional logging for cement bond and density verification; 2) determinations for exact distance from the boron sleeve to hole bottom; 3) a method for "mopping" the casing dry, and to check its dryness during later tests; and 4) drill collar modifications for mandril runs.

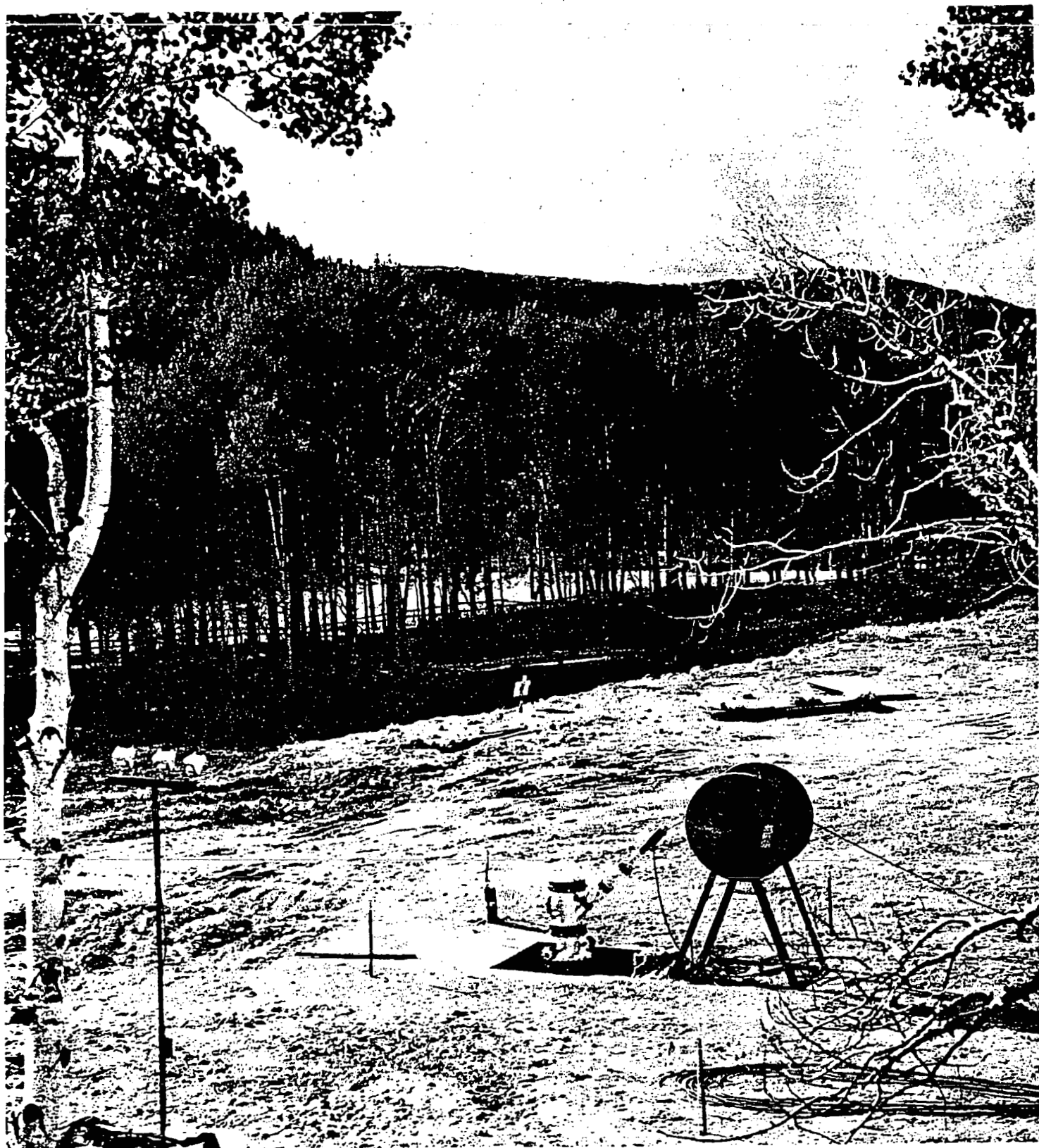


FIGURE 25. THE R-E WELLHEAD

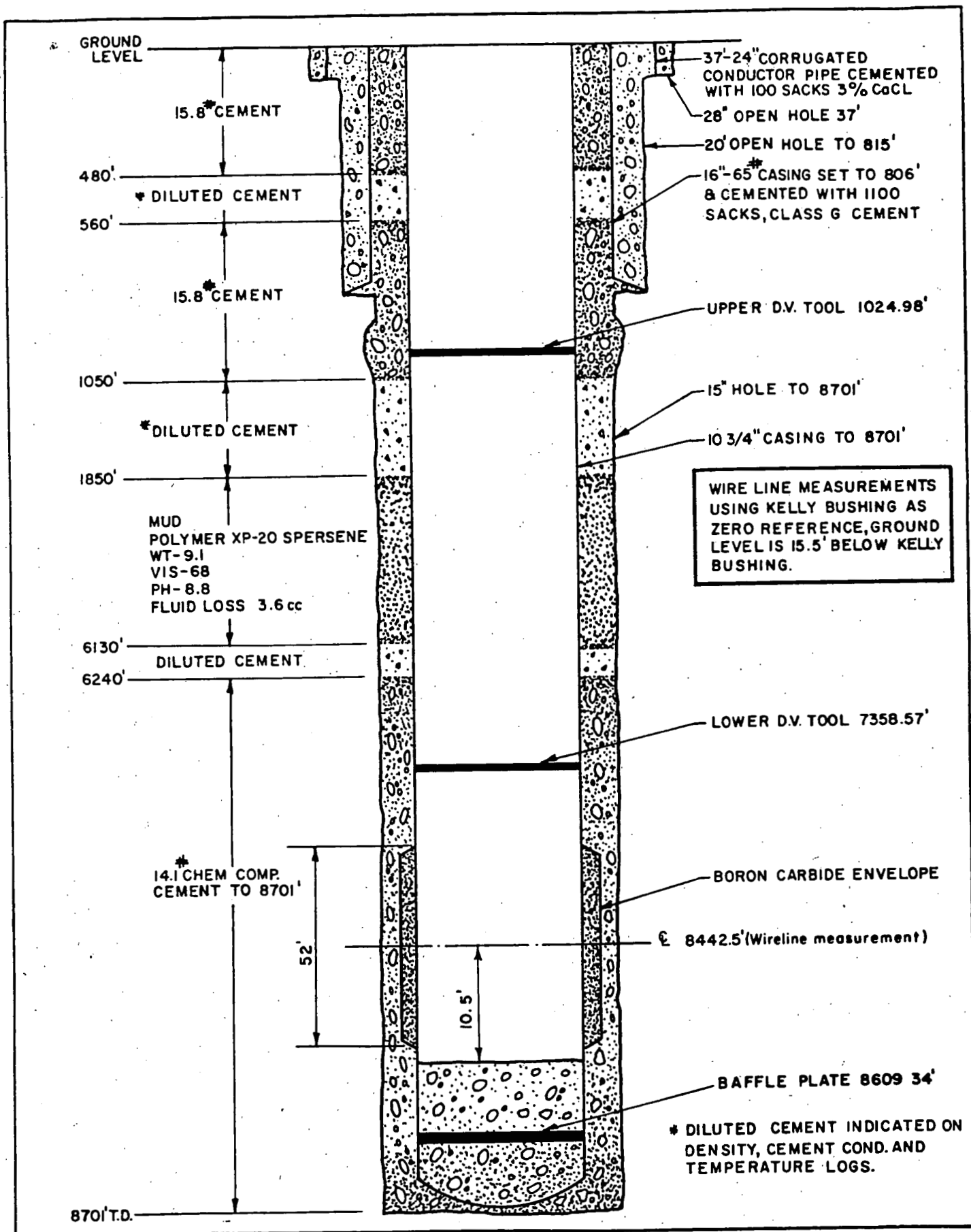


FIGURE 26. PROJECT RULISON CASING SCHEMATIC DIAGRAM

A NV representative was present during the construction of the CP and SGZ facilities and during the device running and stemming operations. At the conclusion of the major construction effort, a Holmes & Narver, Inc., On-Continent Test Division (H&N-OCTD), Engineer inspected the electrical and mechanical aspects to assure compliance with AEC requirements. At LASL's request, NV provided assistance in supervising the stemming of the R-EX. Advice and assistance were provided regarding the decision to cement back this hole, as opposed to continuing the costly, time-consuming, and less sure stemming method that was being used.

In October 1969, buildup of gas pressure at the wellhead occurred faster than anticipated. This caused some concern that a section of casing below the wellhead might be inadequate. NV coordinated the efforts of CER and the Waterways Experiment Station (WES) to place expanding, high-strength cement around the 16-inch surface pipe. This was a protective measure only, since no gas was expected to be behind this pipe.

During the operations period, the CER Site Manager was the contact for DONO's representatives on matters relating to implementation of government and LASL field construction, logistics support, and maintenance requirements.

Office space for the AEC and other personnel was available at the CER office in Rifle, Colorado. CER furnished adequate trailers, storage, and parking areas at the CP and SGZ for use by the various government agencies involved in the project. All trailers at the CP were shock mounted. Commercial power was supplied to the CP, SGZ, and microwave trailers. A standby generator was installed at the CP for telephone, radios, and CCTV at shot time. Generators were also installed at the observer area.

Structural bracing of residences was arranged by CER. As a contingency, CER made arrangements to provide residents with water and house trailers, if damage occurred. Crews were also available to monitor the electrical power system and check and repair, if necessary, utilities to residences. A bulldozer, cement pump, and water trucks were on standby at the CP for use, if required, at SGZ.

#### 5.4.2 Phase III

During Phase III, a NV representative was present to support DONO in matters concerning logistics and construction support furnished by industry and also to direct the construction and logistical support efforts by REECo for the offsite radiological safety program.

## 5.5 COMMUNICATIONS

Communications consisted of fixed and mobile radio networks. A government-furnished mini-microwave system was used for telephone links to the commercial telephone system and was used to supplement the telephone lines for the following:

- A. From the OCC to the Observer Area
- B. For the Joint Office of Information
- C. From the OCC to the Observer Area to assist helicopter dispatching
- D. From the Observer Area to Radio Station KWSR in Rifle, Colorado, to carry the countdown and other information to broadcast stations
- E. For preshot communications to SGZ from the CP (later used for the helicopter dispatch circuit)
- F. For CCTV
- G. For aircraft communications

Additional coverage by a mobile manual repeater stationed at McClure Pass was available, but was not required.

## 5.6 LASL EFFORT

LASL developed the engineering and construction requirements into engineering criteria, and submitted these criteria to the AEC for implementation. The criteria included:

- A. The R-E (size and downhole environment)
- B. The emplacement method (equipment, tools, and hardware)
- C. The firing facility (trailer and electronic rack mounting)
- D. Cabling (type, termination, and location)
- E. The wellhead area (layout, shack, and anchors)
- F. Stemming (type of material, method of emplacement, and equipment)
- G. The wellhead seal (pressure rating)
- H. The schedule of LASL operations
- I. The schedule of Austral- and/or AEC-furnished onsite support (equipment, tools, and manpower) necessary for accomplishment of the LASL operations.

The operation plans and construction drawings and specifications and manufacturer's drawings and literature prepared by Austral, their subcontractors, and suppliers were reviewed to assure compliance with previously submitted criteria.

All field work was monitored; all equipment and hardware tests performed by Austral and their subcontractors were witnessed to assure compliance with LASL requirements. This included supervising the emplacement dry run, the explosive emplacement, and the stemming operations.

Postshot activities by LASL included:

- A. Supervising sealing the wellhead shortly after shot time
- B. Developing criteria for the reentry drilling containment scheme
- C. Reviewing all reentry plans, equipment, and hardware to assure compliance with containment criteria
- D. Witnessing the testing of the containment equipment
- E. Monitoring the reentry operation to assure that all containment requirements were met.

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## CHAPTER VI

### ACTIVITIES OF THE LASL RADIOLOGICAL SAFETY ADVISOR

#### 6.1 INTRODUCTION

In October 1969, LASL furnished a radiological safety advisor to the OD for reentry and initial flaring of gas.

In addition to ensuring that the reentry drilling and initial flaring would be conducted in a safe and efficient manner, these operations were required to be conducted in accordance with procedures submitted to the United States District Court in Denver during litigations. (See Chapter XIV.)

#### 6.2 PLANNING

##### 6.2.1 General

The Radiological Safety Program was concerned with achieving the following objectives:

- a. Timely submission of raw data on all radiological measurements of safety significant to the open file as ordered by the court. It was considered highly important that all data submitted to the open file be accurate and as free from misinterpretation as possible. Since this data was to be submitted within one or two days after collection, the greatest effort was expended to ensure that it was complete and compatible. The possibility of misleading data being reported to the open file resulted in additional notes and information being provided to the open file to ensure proper interpretation of any data that might be questioned.
- b. Minimize and document all radiation exposures to workers and visitors at the site. Controlled access was in effect and every individual entering the site was issued a personal dosimeter. Air samples in the worker's environment were to be taken on a regular basis for the control and documentation of the inhalation exposures.
- c. The amount of radioactivity released to the environment by any effluent stream generated by the drilling or flaring activities was to be documented. Procedures utilized for achieving this objective are discussed in some detail below.
- d. Control of equipment and material leaving the Rulison site to ensure no radioactive contamination. The standard set for release of equipment, i.e., 1,000 disintegrations per minute (dpm) per 100 square centimeters (cm<sup>2</sup>) swiped,

required elaborate and time-consuming procedures for decontamination. All Anti-C clothing used was sent to an authorized commercial facility for washing or packaged for disposal, as appropriate.

All the above objectives were included in a LASL-prepared radiological safety plan used to plan the EIC support. Later, with minor editing, this plan became part of NVO-61, "Project Rulison Post-Shot Plans and Evaluations." NVO-61 became Defendant's Exhibit N and was augmented by a deposition made by the OD's radiological safety advisor to the court. These two documents, plus Appendix A of the court order, "Procedures for Public Dissemination of Project Rulison Raw Monitoring and Related Data" and the Project Rulison Operating Instructions which stated the "Activity Concentration Levels" (Defendant's Exhibit BBBB), established the legal restrictions for reentry operations.

#### 6.2.2 Documentation of Radioactivity Released to the Environment

There were two types of effluent streams produced by the drilling and flaring operations: 1) the continuous stream that must flow uninterrupted if operations are to proceed and 2) the intermittent streams that may be interrupted without stopping the operation. Control of the environmental impact from the continuous type effluent stream required constant, careful, low-level monitoring of the stream and a closing down of operations if certain prescribed limits are approached (Appendix G). The radiological limits were called action concentration levels and were part of the court order. Operations would have ceased, pending further data collection and evaluation, if these levels had been exceeded. The levels were arbitrarily set at 10 times the predicted concentrations for tritium and krypton-85 (as measured, e.g., by STALLKAT, an acronym for system to analyze low-level krypton and tritium), and 10 times the lower limit of sensitivity for those purely precautionary systems (e.g., the gross gamma detector). (See Figure 27.)

The intermittent streams were to be collected and analyzed in convenient increments. Effluent increments with natural background levels of radioactivity would be discharged at the site. Effluent increments above background levels were to be either packaged for disposal at AEC-approved sites or dispersed in a regulated manner approved by the court at rates well below the action concentration levels.

A brief description of the setup for reentry drilling and initial flaring will serve to identify the specific effluent streams anticipated to be generated.

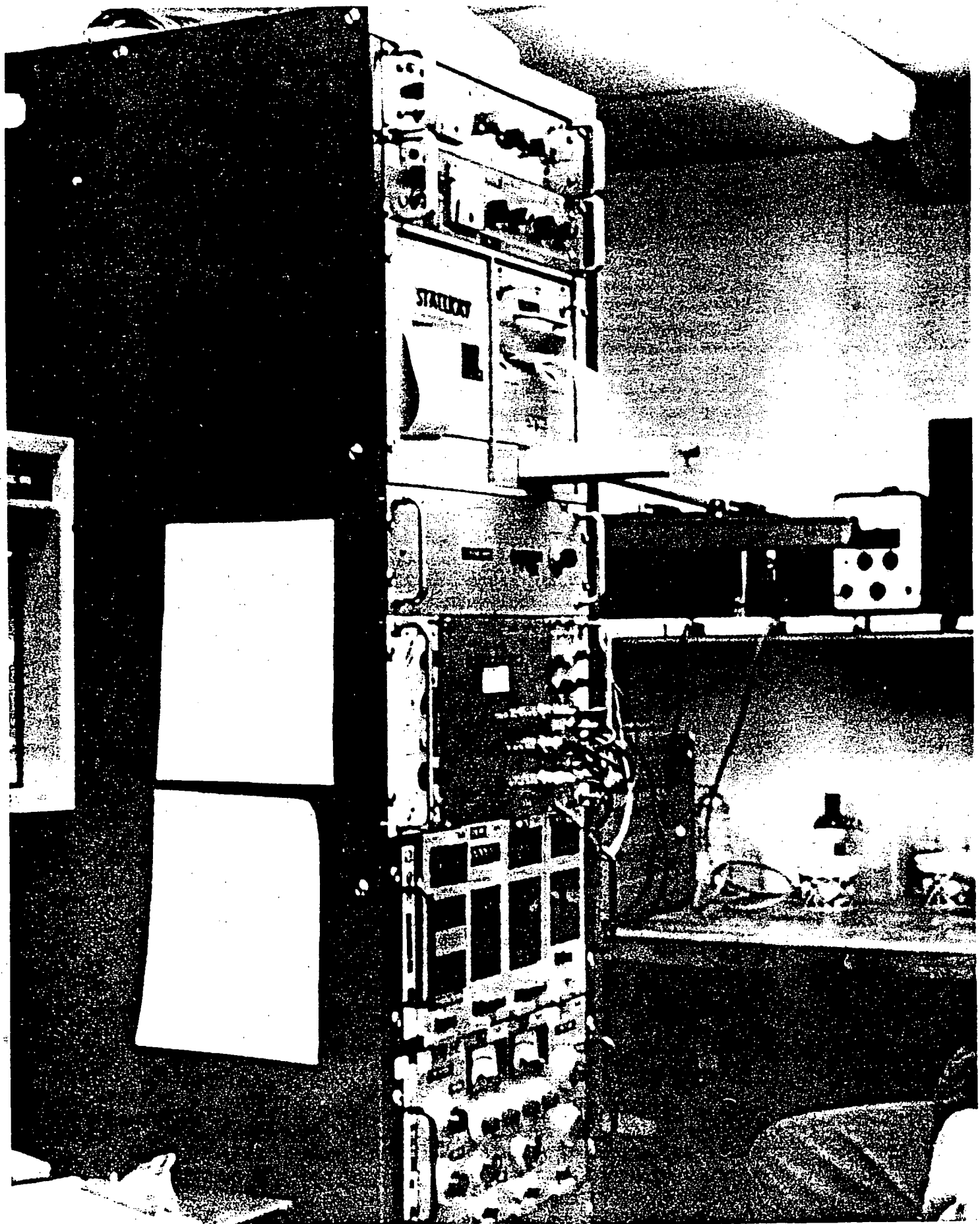


FIGURE 27. THE STALLKAT PANEL  
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To prevent uncontrolled and undocumented releases of radioactively contaminated gas, the procedures developed by LASL at NTS were to be implemented. This involved the use of equipment that would contain gas at nominal pressure encountered during drilling or permit closing in the well if gas at excessive pressure was encountered. However, it is possible that even a well-tested and maintained containment system will leak at an extremely low volume rate. The radioactivity per unit volume of radioactive gas is so high that an extremely low volume leakage rate may be of concern in regard to worker's exposure or documentation of an appreciable release. For these reasons, it had become the LASL practice to surround the containment equipment with a shroud or hood that is exhaust-ventilated at a rate so as to ensure that gas escaping from the containment gear is captured by the air stream. This procedure prevents the radioactive gases from escaping into the work area and provides the means for measuring the quantity of radioactivity ultimately discharged to the environment.

During drilling, a fluid or "mud" is pumped down the drill hole to the drilling point and then circulated back to the surface. This mud carries up drilling chips and absorbed gas present in the drill hole. Thus, on return to the surface, the drilling mud generates two effluent streams: 1) the drilling chips that are separated from mud by passing the drilling mud over a shaker table and 2) the absorbed gas that is released when the drilling mud is recycled through the mud tanks. At Rulison, this off-gas was expected to be radioactive and consequently the amount released would have to be documented by enclosing the mud tanks with exhaust-ventilated hoods. At Rulison, the exhaust air from the drill rig shroud and from the hoods over the mud tanks were to be combined and discharged at a single stack. The specified one air change per minute for the hoods and shroud was expected to keep the concentration of gas in the ventilation system below the lower explosive limit.

For planning purposes, it was anticipated that the drilling chips would be collected at the end of the shaker table and packaged in steel drums. Uncontaminated chips were to be discarded on the ground at the drill site; contaminated materials were to be sealed in the drums and held for ultimate disposal as directed by the AEC. Contaminated drilling fluids would be permanently left in the cavity after communication was reached.

During the flaring operation, it was planned to pass the gas through the phase separator that would remove water and a fraction called distillate which is composed of condensable organic solvents. The gas passed by the phase separator was

to be burned at the flare stack and the combustion products dispersed into the atmosphere. The collected distillate and water were to be stored in holding tanks and periodically injected into the flare for ultimate dispersal into the atmosphere.

In the planning stages, only the following effluent streams were anticipated during drilling: 1) the gas leakage from the containment gear and the off-gas from circulating drilling mud exhausted by the ventilation system and discharged to the atmosphere through a stack and 2) the drilling chips separated from the recirculating drilling mud to be dispersed on the ground at the drill site or if contaminated, packaged for ultimate disposal.

During flaring, the main effluent stream would be the natural gas that was to be burned at the flare stack and the resulting combustion products dispersed into the atmosphere. (See Figure 28.) The water fraction separated from the gas was to be converted to steam and dispersed into the atmosphere by being injected at the base of the burning flare. The distillate was also to be injected into the flare and its combustion products dispersed into the atmosphere.

Monitoring of the exhaust ventilation air stream during drilling and the gas stream during flaring was to be accomplished by an instrument developed by LLL for Gasbuggy. The use of this STALLKAT instrument at Rulison was presupposed before LASL was assigned rad-safe responsibility. The importance of its use grew until its continued operation during flaring was established as a requirement by the court. The fact that it was a one-of-a-kind experimental instrument was a major worry, overshadowed, however, by the opinion that it had been "proven" at Gasbuggy. Though certain drawbacks with STALLKAT were readily seen, not the least of which was a poor sensitivity to tritium, it was clearly the best available system. Its lack of tritium sensitivity, however, would require assuming a constant tritium-krypton ratio for many of the smaller release estimates. One advantage of the instrument for documenting the release of tritium and krypton at the extremely low levels anticipated was the fact that EIC personnel had gained considerable experience in its operation and maintenance on the Gasbuggy operation.

As a safety measure, the exhaust air ventilation system was also to be monitored by a system of five explosimeter heads placed at various points within the system. Instrument read-out and audible alarms were to be located in the instrument trailer and duplicate audible alarms placed in the access control trailer.

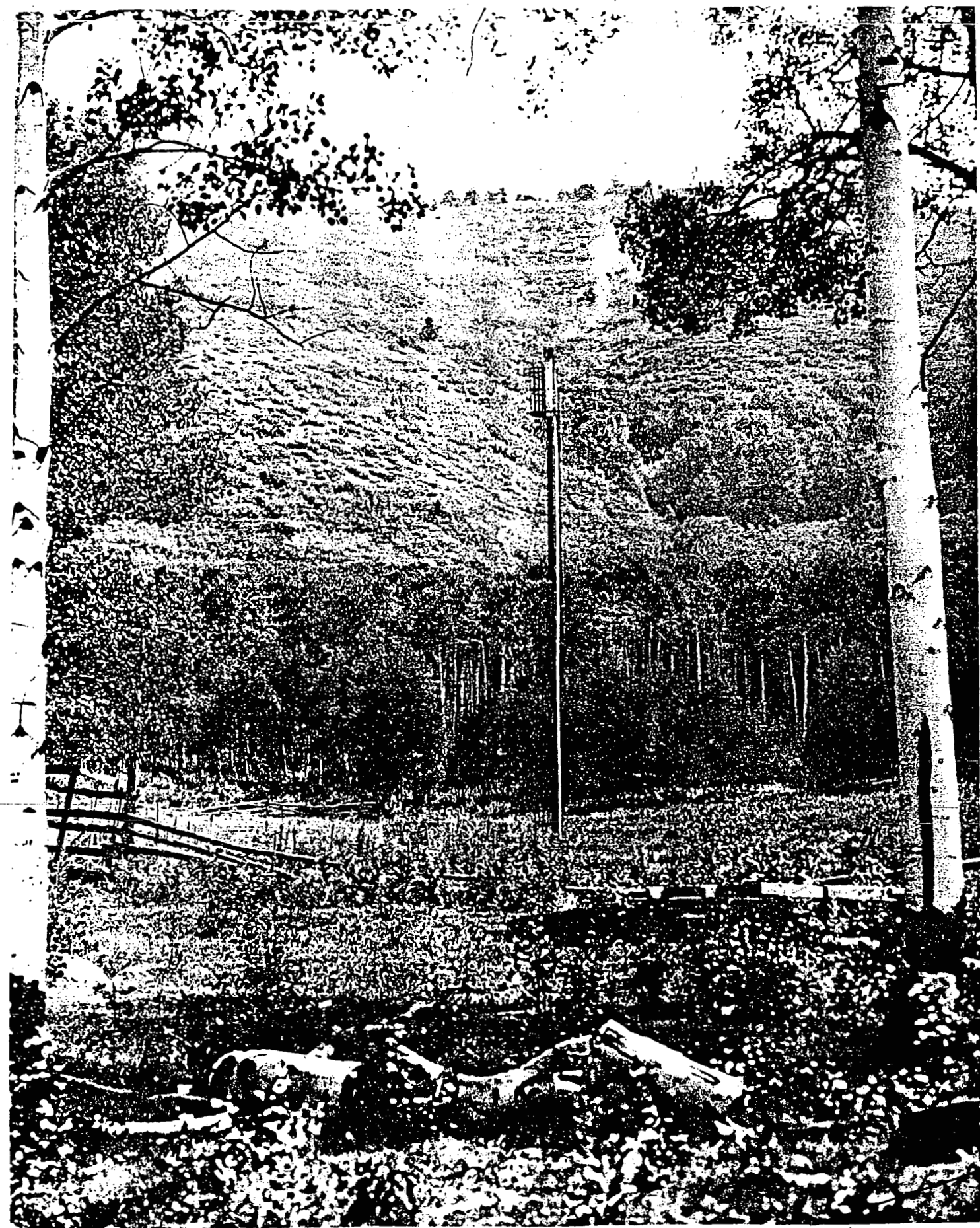


FIGURE 28. NATURAL GAS BEING BURNED AT THE FLARE STACK

Monitoring of the drilling chips was planned to be accomplished by a sensitive gamma-ray scintillation detector suspended over the shaker table. Chips giving rise to positive readings on this instrument were to be packaged and held for further assay and ultimate decision on disposal.

The water fraction collected from the flare gas was to be subjected to a tritium analysis, gamma pulse height analysis, and a beta count of suspended solids. The distillate fraction was to be oxidized to water and monitored by the same procedures.

### 6.3 ONSITE OPERATIONS

Two facts were ultimately responsible for many of the required changes in the operational concepts. The first was the necessity to undertake the second or remedial drilling operation which was not anticipated. The other aspect was the difficulty during planning sessions of making aware to inexperienced people the dangers involved in working with radioactive materials. This lack of understanding resulted in field changes due to inadequate facilities (e.g., chip handling facility) or to equipment usage where radiological safety was not considered.

The monitoring systems employed during the operational period are summarized in Table 2. The table reflects the growth in both the scope and the numbers of the items that were eventually included on the daily report to the open file.

#### 6.3.1 Preliminary Operations

LASL commenced preliminary operations on April 7, 1970, a date several weeks in advance of scheduled start-up. The rescheduling left no time to accomplish a LASL-requested checkout and demonstration of the EIC laboratory and process stream sampling equipment. The absence of this final checkout made it necessary to improvise many of the plumbing details in the field and contributed to several later operational errors. When finally assembled, it was evident that the sampling lines might result in a cross-connection between the air ventilation duct and the gas line, and a rearrangement was required. Another major difficulty in establishing the planned setup was the necessity to construct three versions of the ventilation system before obtaining one that would meet design specifications.

Other predrilling activities included assistance in a re-sampling of the LASL-controlled R-E wellhead. Some of the sampled gas was used to establish a correlation between

STALLKAT and TRY-KRY, a proprietary instrument, suggested as an operational STALLKAT backup when proven satisfactory. The crosschecks were promising with TRY-KRY being more sensitive to tritium than STALLKAT.

Rad-safe indoctrination of the drilling and construction crews, most of whom had no previous exposure to rad-safe procedures, was accomplished.

#### 6.3.2 Drillback Operations

Postevent drilling began on April 28. Problems with assaying rig associated fluids (mostly oily rig wash-down water, rain, or melting snow, diesel oil, mud, etc.) before discharge were immediately encountered. This source of insult to the environment was not considered to be important in the reentry planning, since it seemed entirely possible that no radioactive materials at all would reach the surface during drilling. Consequently, provisions were made only for a local holding pond (30,000 gallons) to be used as required. The seemingly reasonable assumption was made that all fluids could be assumed free of contamination until radioactivity was detected in the recirculating system. Detection was to be accomplished in three ways: 1) periodic checks on the mud samples for tritium or gross gamma activity, 2) continuously looking at off-gas for tritium and krypton-85, and 3) a sensitive gamma detector over the shaker table which could detect krypton-85. Nevertheless, it was decided to assay all water, even without positive signals from the recirculating mud system, as an extra precaution. Two 500-gallon tanks and later an additional 9000-gallon tank were installed to provide time for sampling and assaying while collection continued. Additional sampling, counting, and reporting regimes were necessitated by this procedure. Samples of each tank were analyzed for radioactivity prior to releasing uncontaminated water to the large plastic lined pit where the fluids were held for eventual transfer by pipeline to the lower mud pit or, if contaminated, pumped to the holding tanks. Differentiation between contaminated and uncontaminated water was established at three standard deviations above the mean of the instrument background count rate.

As an operational check on the approach to communication with the cavity, bulk samples of recirculating drilling mud were analyzed regularly for gross gamma activity and the water fraction for tritium. No mud was found contaminated during the initial drilling.

Drilling chips were collected in barrels and held until assay of representative samples by gamma spectrometry assured local dumping to be permissible. No chips were



found that exceeded natural background activity during the initial reentry drilling.

The first positive indication of other than natural radioactivity from the cavity was noted on the evening of the 89th day of drilling. Positive readings with a hand held beta-gamma detector were seen when breaking joints while coming out of the hole, apparently krypton gas. Pressure in the pipe was bled into the mud return and explosimeters in the shrouds and air vent line gave positive indication as did the STALLKAT krypton channel. Mud samples, swipes, and air and vapor samples in the work area were all negative. The hole was completed with no further radiation indications although explosive mixtures were detected in the shroud.

No detectable activity was found in the mud or water displaced from the annulus between the production tubing and the casing. The containment stack and shroud were moved and monitored, again only as a precaution, before release. The Christmas tree was installed in preparation for a brief flow test through the flow control unit (DWC). (See Figure 30.)

#### 6.3.3 Initial Flare

On August 1, the initial flow of gas was made through the DWC. The EIC-operated equipment was all in service and responded as expected. Release estimates measured during this and subsequent flows are summarized in Table 6.

#### 6.3.4 Tear Down

After the initial flow test of August 1, the drilling equipment was dismantled and released following monitoring. Of the equipment released from the site, only the DWC unit and one mud tank required decontamination, but simple water flushing was all that was required, since tritium activity in fluids had not exceeded a few hundred pCi/ml. All other piping which has passed contaminated fluids was marked, the ends covered and stored pending reuse onsite. All contaminated solids, primarily barrels of soil from spills, were stored in a fenced area pending disposal.

No LASL Radiological Safety Representative was onsite from August 5 through 11, during which time the separator, flow prover, and associated plumbing were installed. All the EIC-operated equipment, much of which had been in continuous operation since May, was given routine maintenance, equipment was set up for calibration flaring, and recounts of air samples continued.

### 6.3.5 Calibration Flaring (Initial Attempt)

#### a. Preparation

On August 13, 1970, the annulus was bled down through the flare stack three times. During the first two flows, the STALLKAT was not in operation due to an error in valve settings. The error was corrected for the third and largest flow and release estimates for the first two flow periods were established by scaling on basis of flow to this release. (See Table 6.)

During temperature probe runs on August 15, 1970, the well was flowing and the EIC equipment was operational. Several more small, unavoidable releases at the Christmas tree were estimated as shown in Table 6. A radiation-controlled area was established around the tree area for contamination control. All downhole equipment used was successfully decontaminated with steam to below the now established limit of 1,000 dpm per 100 cm<sup>2</sup> by swipe. One wire line was not cleaned, but stored onsite for future use.

The first attempt at calibration flaring was made August 18, 1970. Flow was possible for only a short time before the flow line was plugged. The separator was inerted, cut open, and found to be clogged with chips. Monitoring equipment performed satisfactorily with krypton-85 and tritium concentrations and ratio much as expected.

During the next six days, support was provided in several abortive attempts to free up the well. Three major releases were measured and most of the special equipment was decontaminated. Again, all plumbing known to have passed potentially contaminated fluids was labeled, ends bagged, and stored for future use inside the R-E fence.

#### b. Remedial Work

The decision was made to perform remedial work on the well, requiring erection of a drilling rig, containment gear, and associated equipment. At the planning meeting held in Houston on August 27, 1970, there was general agreement on the desirability to establish a system of contamination control drip pans under the pipe rack, drill rig, and all contaminated fluid handling equipment, except the mud tanks. Additional EIC personnel were requested because of anticipated additional contamination control, decontamination,

and water handling chores. An extra drill hand per shift was also suggested to avoid excessive traffic into and out of the controlled area.

c. Remedial Drilling Setup

Essentially the same drilling setup was used for the remedial drilling. Improvements were obtained in the ventilation system and the drip pans and more efficient containment stack shroud was possible. Explosimeters were installed as before.

The Christmas tree was removed, disassembled, and decontaminated prior to leaving the site for reworking.

A radiation controlled area around the drill rig was established on September 11, 1970, to avoid tracking of any contamination to the surrounding area and to monitor personnel leaving the controlled area, although the anticipated levels presented no health hazard. The single entrance to the area was established at the rig stairs using a manned station for equipment issue and return. Complete anticontamination gearshoe covers, coveralls, and gloves were required inside the area. The controlled area was defined by the extent of the drip pans and further delineated with signs and ribbon. Access to most parts of the rig and equipment could be reached via the drip pans but some duck-board paths with plastic under liners were later installed for convenience. Swipes of the doghouse area and the exit near the access stairs were taken daily and surfaces cleaned when found contaminated.

Remedial operations began on September 12, 1970, with removal of the Otis plug. All procedures developed during the initial reentry phase were in force for the remedial work.

Although the drip pans helped contamination control, several spills of contaminated fluid did occur. All spillage could have been controlled if the pans had been extended under the mud tanks. As much contaminated dirt as possible was excavated and barreled after each spill but in some instances, removal had to be deferred until equipment was moved. One spill caused low-level tritium contamination to reach the large, plastic lined holding pit, and no further release from it was made.

Decontamination was also a more demanding chore as tritium levels in contaminating fluids were now much elevated, approaching 0.1 microcuries/milliliter. Steam alone or steam and detergent were not sufficient to assure that nothing was released from the site above the 1,000 dpm per 100 cm<sup>2</sup> by swipe limit. Tritium contamination trapped in grease was the major concern and the procedure finally devised was to disassemble and degrease the equipment completely before the initial swipe check. When items were visibly clean, there was rarely any contamination found by swipe. Two commercial products, an emulsifier, "Emulsit," and a detergent, "Steamzall," were very useful.

Disposal of stored contaminated water was started on September 21, 1970, by injecting it into the gas flame. During this period, the water was first converted to steam and injected into the flare established by CER and Austral from gas supplied by the Western Slopes Natural Gas Association. About two gallons per minute could be dispersed in this way. Later, when the flare was established with high-pressure Rulison gas, conversion to steam was not required and dispersal of nine gallons per minute was possible. (See Table 4.)

Gas bubbles trapped in the downhole fluids caused a number of small and two significant releases (see Tables 5 and 6). Total volumes for releases through the DWC unit were measured or estimated by Austral; the smaller releases through the air vent system were crudely estimated using the vent line explosimeter strip chart recordings.

d. DWC Flaring

Flows of the completed reworked well began on October 4 and continued until October 7, 1970, the last few hours during an 11-inch snowfall. Flare line monitoring equipment operated well; the release is recorded in Table 6. Some quite active tritium material fell near the base of the stack early in flaring and some tritium activity was "snowed out" of the flare. Based on several samples taken at radial distances up to 36 feet from the base of the flare stack, an estimate of less than 3 millicuries (mCi) of tritium deposited on the ground during the early phase of the flaring was made. During the snowfall, an estimated 40 mCi of tritium fell within an approximate 300-foot circle around the flare stack, based on 12 snow samples collected around the stack. During the same episode, as much as 7 mCi was deposited on the controlled area, much of which was collected in the drip pans or the plastic lined pit.

e. Teardown of Remedial Drilling Setup

Decontamination of the equipment was the primary activity prior to high rate flaring. All pieces of equipment exposed internally to contaminated fluids (mud pumps, pipe joints, subs, mud tanks, shrouds) were disassembled as far as possible and degreased to pass the swipe test. Rig floor, draw works, doghouse, lower part of the derrick, and subbase parts which were over drip pans were steam cleaned. All ladder rungs and other likely contaminated surfaces on the derrick were wiped down and checked. By October 16, 1970, all drilling equipment had been cleaned and checked. The drip pans were left in place for the remainder of the operation.

All areas outside of pans where spills had occurred were outlined with lime and representative samples taken of each area. While the total tritium left in all these areas was estimated at less than 15 mCi, laborers dug out and barreled each area to a depth of several inches prior to grading and regravelling the area. It is estimated that less than 1 mCi remained as a result of all spills.

Water disposal by steaming and flaring was continued.

An unscheduled flow was done on October 23, 1970, to free the clogged tree. Release data is presented in Table 6.

f. Reentry Well Gas Sampling

The demands of the program for reentry well gas sampling and analysis were present over a number of operational stages. Much of this program was predicated on the original orderly drilling schedule; the remedial work during August and September, 1970, however, required that many of the samples be taken on an "opportunistic" basis. For all of these, the LASL Group H-8 representative was responsible for ensuring that the sample was taken in a timely and proper manner and that it did not interfere with or hinder the containment system. Because of the frequent and sudden changes in procedures and schedules, continued attention was devoted to what the immediate sampling schedule was and whether or not a sample should be taken.

From July 30 to October 24, 1970, a total of 22 samples of the reentry well gas were secured.

6.4 SUMMARY

No onsite personnel received whole body beta or gamma doses during the report period, as measured by thermoluminescent dosimeters (TLDs).

Urine assays for tritium showed no positive results. No air samples taken in work areas showed above background activity except for tritium water vapor during flaring periods. The highest air concentration seen was  $10^5$  times less than the level established by the AEC Manual 0524 for occupational workers. Analysis of onsite vegetation and soil samples showed only worldwide fallout and natural activity, except for areas with known spills and the close-in area contaminated with fallout or snowout from the flare stack.

TABLE 2.--Project Rulison Monitoring Systems

No.	System	Location	What Measured	When Operated	Frequency
1	STALLKAT <sup>a,b</sup>	Flare or air vent line	Kr and T concentrations	When shrouds ventilated or gas flare line in use	Variable, time integration (1-60 min.) plus continuous strip chart
2	Particulate filters and charcoal cartridges <sup>b</sup>	Air vent line and gas flare line	Particulate nuclides ( $\beta, \gamma$ ) and $^{131}\text{I}$	When air vent stream and gas flare line in use	Changed once/8 hr. shift
3	STALLKAT freeze trap <sup>b</sup>	Flare or air vent line	Tritium concentrations due to water vapor in air gas stream	When shrouds ventilated or gas flare line in use	Changed usually once/8 hr. shift
4	Gross Gamma <sup>a,b</sup>	Air vent and gas flare lines	Gamma levels in air and gas streams	When gas and air streams in use	Continuous reading
5	Air Samples <sup>a</sup>	Work area	Particulate nuclides ( $\alpha, \beta, \gamma$ ) and $^{131}\text{I}$	During work times as appropriate	Once a day or once/8 hr. shift as appropriate
6	Krypton-chamber <sup>a,b</sup>	Flare or air vent line	Kr concentrations	When two lines in operation--the one not monitored by the STALLKAT. Otherwise used as STALLKAT backup	Variable time integration (1 min. to several hours) plus continuous strip chart
7	Water and Condensate <sup>b</sup>	Holding tanks	Tritium and $\gamma$ spectrum	As needed prior to injection into flare	

See footnotes at end of table, page 79.

TABLE 2.--Project Rulison Monitoring Systems (Cont.)

No.	System	Location	What Measured	When Operated	Frequency
8	Special Gas Samples <sup>b</sup>	Gas flare line	Gross $\beta$ , Kr concentrations $\gamma$ spectrum	As desired	
9	TLD personnel dosimeters <sup>b</sup>	On all onsite personnel	$\beta$ - $\gamma$ dose	As needed	Changed monthly
10	Vegetation and Soil Samples <sup>b</sup>	1000-foot arc around site	$\gamma$ spectrum	End of the month	Monthly when not covered by snow
11	Site Air Freeze Trap <sup>c</sup>	In work area	T concentration due to water vapor in the air	During work times as appropriate	Changed usually once/8 hr. shift
12	Holding Tank Water <sup>c</sup>	Sump Area near rig	Tritium gross $\gamma$	Before dumping into holding pit	As needed
13	Drilling Chips <sup>c</sup>	Buckets near rig	$\gamma$ spectrum	Before releasing to open disposal	As needed
14	Recirculating Mud Stream <sup>c</sup>	North mud tank	Tritium	During mud circulation	Every 2 hours
15	Water puddles on location <sup>d</sup>	Work area	Tritium	Checking suspected spills	As needed
16	Swipes <sup>d</sup>	Checking for contamination where necessary	Tritium, gross $\gamma$		As needed

See footnotes at end of table, page 79.



TABLE 2.--Project Rulison Monitoring Systems (Cont.)

No.	System	Location	What Measured	When Operated	Frequency
17	Pipe monitoring <sup>d</sup>	Open pipe	$\beta, \gamma$ by hand held Geiger-Mueller	During trips	As needed
18	Explosimeters <sup>a, d</sup>	On Christmas tree rig and in vent system	Explosive mixtures	When systems on line	Continuous recording
19	Snow samples <sup>d</sup>	Within 1,000' radius	Tritium	As desired	
20	Urine assay <sup>d</sup>	Specimens from onsite personnel	Tritium	During work on the well	Usually once/8 hr. shift
21	Gross Gamma <sup>a, d</sup>	On rig, in mud tanks, on Christmas tree	Gamma levels	When the heavy equipment was set up on location	Continuous recording

- a. Had audible alarms.  
b. Requested and reported to the open file.  
c. Not requested, but was reported to the open file.  
d. Not requested, not reported to the open file.

TABLE 3.--Reentry Well Gas Samples

Date	Time	Agency	Analysis (pCi/cc)	
			<sup>85</sup> Kr	<sup>3</sup> H
July 30, 1970	2400	EPA/NERC	320	320
August 1, 1970	2013	Isotopes/101	318	318
August 1, 1970	2015	LLL (1)*	188	223
August 1, 1970	2015	Oak Ridge National Laboratory (ORNL)	153	178
August 1, 1970	2020-2050	EPA/NERC	110-180	210-360
August 1, 1970	2024	Isotopes/102	180	180
August 1, 1970	2024	LLL (2)*	150	175
August 13, 1970	1701	Isotopes/AF104	260	330
August 13, 1970	2150	Isotopes/AF103	150	200
August 22, 1970	1105	EPA/NERC	90	140
August 22, 1970	1145	EPA/NERC	250	110
October 5, 1970	0218	LLL (1)*	145	205
October 5, 1970	0230	ORNL (1)	161	168
October 5, 1970	0235	ORNL (2)	157	171
October 5, 1970	0245	LLL (2)*	151	173
October 5, 1970	0245	Isotopes	184	180
October 5, 1970	0950	EPA/NERC	190	88.0
October 5, 1970	1515	EPA/NERC	170	62.0
October 5, 1970	1507	LLL (3)*	148	170
October 7, 1970	0858	Isotopes	160	200
October 7, 1970	0900	LLL*	150	174
October 7, 1970	1120	Isotopes	25.0	62.0

\*UCRL-50986--Gas Analysis Results for Project Rulison Calibration Flaring Samples, C. F. Smith, January 7, 1971, Lawrence Radiation Laboratory.

TABLE 4.--Tritium Released in Water

Dates	Method	Amount (gal.)	Range of Tritium Concentrations	Tritium Released (Ci)	Gross $\beta$ Activity Released (mCi)
September 21 - October 24, 1970	Flared	$6.90 \times 10^4$	$5.2 \times 10^0$ to $6.1 \times 10^4$ pCi/ml	9.1	$0.29^c$
August 1 - October 23, 1970 <sup>a</sup>	As water vapor in gas and air <sup>b</sup>	$6.09 \times 10^3$	$2.3 \times 10^2$ to $4.0 \times 10^6$ pCi/m <sup>3</sup> of gas	0.53	----
	TOTALS	$7.51 \times 10^4$		9.6	0.29

- a. Dates included August 1, 13, 15, 18, and 22, 1970; September 4 and 17, 1970; October 8 and 23, 1970.  
b. Measured in air vent or gas flare line by the STALLKAT freeze trap.  
c. Predominately natural  $^{40}\text{K}$ .

TABLE 5.--Minor Releases

Date	Events	Estimated Vol. of Gas Released (ft <sup>3</sup> )	Estimate of mCi Released		Radiation Seen By
			<sup>85</sup> Kr	<sup>3</sup> H <sup>a</sup>	
July 31, 1970	Displacing Water <sup>b</sup>	Trace	----	----	Nothing
July 31 - October 26, 1970	Bleeding down lubricator, Christmas tree, to atmosphere	800	3.4	6.8	Nothing
September 9, 1970	Bleed off annulus and tubing	< 10	0.065	0.13	Kr-chamber
September 13, 1970	Recirculating water into North Mud Tank <sup>b,c</sup>	300	1.5	3.0	STALLKAT-Kr
September 22-28, 1970	Gas bubbles in recirculating fluid <sup>b,d</sup>	$1.6 \times 10^4$	78	154	STALLKAT-Kr
September 25, 1970	Bubbles through DWC	$2 \times 10^3$	8	16	Kr-chamber
September 29, 1970	1) DWC dump into North Mud Tank <sup>b</sup>	600	2.5	5.0	Nothing
	2) DWC dump	5,000	13	26	Kr-chamber
October 5, 1970	Ruptured burst plate line <sup>b</sup>	3,200	13	26	Kr-chamber
October 23-26, 1970	Burp Christmas tree through separator and gas flare line	510	1.6	3.2	STALLKAT-Kr
	TOTALS	$2.84 \times 10^4$	120	240	

- a. Estimates are based on a 2:1 tritium to krypton ratio.  
 b. Release through air vent line.  
 c. Gas bubbles also escaped out view box on mud return line.  
 No estimate of volume.  
 d. Total depth of 8,358 feet reached on September 29, 1970.

TABLE 6.--Major Releases Through the Flare Stack

Date	Event	Vol. of Flared Gas (ft <sup>3</sup> )	Curies Released in Flared Gas <sup>a</sup>		Average Concentrations (pCi/cc)		
			<sup>85</sup> Kr	<sup>3</sup> H	Krypton Chamber	STALLKAT	
						<sup>85</sup> Kr	<sup>3</sup> H
August 1, 1970	Initial flare	9.1 x 10 <sup>4</sup>	0.15	1.8	184	165	520
August 13, 1970	Annulus bleed down	8.8 x 10 <sup>4</sup>	0.36 <sup>b</sup>	1.1 <sup>b</sup>	185	146	429
August 15, 1970	Run temperature probes	4.5 x 10 <sup>5</sup>	1.7	2.8	190	135	221
August 18, 1970	Calibration flare attempt	1.8 x 10 <sup>5</sup>	0.77 <sup>b</sup>	3.2 <sup>b</sup>	166	153	636
August 22, 1970	Attempt to unplug	1.9 x 10 <sup>5</sup>	0.86	2.8 <sup>b</sup> / 2.7	178	162	499
August 23, 1970	Attempt to unplug	9.0 x 10 <sup>4</sup>	0.41 <sup>b</sup>	1.5	c	150	c
August 24, 1970	Bleeding down	8.7 x 10 <sup>4</sup>	0.47	1.2	c	c	c
September 24, 1970	Flow through DWC	5.0 x 10 <sup>4d</sup>	0.20 <sup>e</sup>	0.40 <sup>f</sup>	40.7 <sup>g</sup>	---	---
October 4, 1970	Flow through DWC	2.5 x 10 <sup>6</sup>	11 <sup>b</sup>	27 <sup>b</sup>	---	152	378

See footnotes at end of table, page 84.

TABLE 6.--Major Releases Through the Flare Stack (Cont.)

Date	Event	Vol. of Flared Gas (ft <sup>3</sup> )	Curies Released in Flared Gas <sup>a</sup>		Krypton Chamber	Average Concentrations (pCi/cc)	
			<sup>85</sup> Kr	<sup>3</sup> H		STALLKAT	
						<sup>85</sup> Kr	<sup>3</sup> H
October 5, 1970	Flow through DWC <sup>h</sup>	2.0 x 10 <sup>6</sup>	8.7 <sup>b</sup>	17 <sup>b</sup>	---	151	292
		1.8 x 10 <sup>6</sup>	6.3 <sup>b</sup>	20 <sup>b</sup>	---	129	415
October 6, 1970	Flow through DWC	4.0 x 10 <sup>6</sup>	16 <sup>b</sup>	31 <sup>b</sup>	---	138/138 <sup>i</sup>	191/325 <sup>i</sup>
October 7, 1970	Flow through DWC	1.2 x 10 <sup>6</sup>	5.0 <sup>b</sup>	9.6 <sup>b</sup>	---	145	281
October 23, 1970	Flush the well	1.9 x 10 <sup>4</sup>	0.06 <sup>b</sup>	0.12 <sup>f</sup>	149	110	1130 <sup>j</sup>
	TOTALS	1.27 x 10 <sup>7</sup>	52.3	119			

- a. These values are obtained from STALLKAT data unless otherwise noted.
- b. Release calculated using average concentration in this period. All other releases are calculated using integral data for discrete time periods.
- c. Average concentrations were not calculated.
- d. Austral estimate. The flow was on an intermittent basis.
- e. Estimated from a concentration of 140 pCi/cc.
- f. Tritium:krypton ratio assumed to be 2:1.
- g. Due to intermittent flow, the krypton chamber did not see equilibrium concentration.
- h. Two entries are made because there were two distinct flow periods.
- i. The calibration appeared to change on the STALLKAT. Two different calibration factors were used. The gas flow was continuous.
- j. Believed due to STALLKAT troubles.

## CHAPTER VII

### ONSITE RADIOLOGICAL SAFETY

#### 7.1 BACKGROUND

EIC was assigned by the AEC/NV under Contract AT(26-1)-294 to provide the onsite radiological safety support for Project Rulison. Radiological support services included the following activities:

- A. Installation and operation of the Remote Area Monitoring System (RAMS) around SGZ for effluent documentation and hazards evaluation (detonation phase only)
- B. Around-the-clock site surveillance by certified radiation monitors
- C. Environmental sampling
- D. Operation of onsite sample preparation and radiological measurements trailers
- E. Installation and operation of continuous effluent monitoring systems during postdetonation activities
- F. Radiation area access control
- G. Personnel dosimetry
- H. Instrument maintenance and calibration
- I. Control of radioactive and contaminated materials and equipment
- J. Report preparation (included daily reports to open file during postshot activities)
- K. Maintaining the capability to respond to radiation incidents of an emergency nature

Onsite operations began on April 21, 1969, with the arrival of the EIC Project Manager and the radiological measurements trailer. The EIC operations continued onsite until a four-month delay in the readiness date was announced. The EIC personnel resumed operations onsite on August 7, 1969, remaining until the week following the detonation. Subsequently, until chimney reentry began, surveillance was continued on a monthly trip basis.

Beginning with the detonation phase, and during all operations through completion of the production testing, there were one or more AEC/NV representatives at the Rulison location representing DONO and the Radiological Operations Division (ROD). The ROD representative coordinated and continuously evaluated the onsite and offsite radiological monitoring and sampling programs.

## 7.2 EFFLUENT DOCUMENTATION

### 7.2.1 Detonation Phase

Eight RAMS detectors were installed in a circular array around SGZ. Each detector was approximately 300 feet from SGZ. One RAMS unit was placed on the SGZ wellhead and one unit was located in the CP area.

All RAMS units, including the SGZ wellhead unit, survived the ground shock. No radiation level above normal background was detected by any of these units.

A gamma scintillation detection system with an associated strip chart readout was installed on the wellhead prior to the site being placed in a caretaker status. Action guidelines were established for indicated radiation levels in excess of 3 milliroentgen per hour above background. This unit was read at weekly intervals.

### 7.2.2 Reentry Drilling

The reentry drilling operation was designed to reenter the chimney by entering the R-EX and drilling out the hanger and setting a whipstock at 6,575 feet, then completing the well by hanging a 4 1/2-inch liner to the fracture zone (see Figure 6). Drilling operations commenced on April 28, 1970, and were completed in July 1970.

EIC installed monitoring systems and analyzed drilling fluids for radioactivity. Prior to the start of drilling, EIC installed and calibrated systems to continuously monitor all drilling mud, chips, and gas. Remote monitors for explosive gas mixtures around the drill rig, tanks, and exhaust air ventilation system were installed and continuously operated by EIC personnel. All monitoring systems were equipped with alarms to trigger a preset warning level at which time the cause of the alarm was investigated and reported to the onsite LASL and AEC/NV ROD representative.

Onsite radiological analysis capability was provided by a radiological analysis laboratory trailer; this trailer contained gamma scintillation detectors with a multichannel analyzer, a gas flow proportional alpha and beta counter, and a liquid scintillation spectrometer. Sample preparation facilities were housed in a separate trailer. In addition, an oxidizer was provided to completely combust periodic samples of organic materials and natural gas from which the water of combustion was collected and analyzed for tritium.

Additionally, portable radiation detectors and industrial hygiene hazard detection equipment for toxic and explosive gases was provided by EIC.



Immediately, problems with rig-associated fluids (mostly oily rig wash down water, rain or melting snow, diesel oil, and mud) were encountered before being discharged. Detection of contaminated fluids was accomplished by: 1) periodically checking mud samples for tritium or gross gamma activity, 2) continuously looking at off-gas for tritium and krypton-85, and 3) using a gamma detector over the shaker table which was capable of detecting krypton-85.

As an extra precaution, all water was assayed. Two 500-gallon tanks and a 9,000-gallon tank were provided for this purpose. Samples, swipes, and air and vapor samples in the work area checked out negative. The hole was completed with no further radiation indication although explosive mixtures were detected in the shroud.

No detectable activity was found in the mud or water displaced from the annulus between the production tubing and the casing. As a precaution measure before release, the containment stack and shroud were removed and monitored. The Christmas tree was installed in preparation for a brief flow test through the DWC unit. (See Figures 29 and 30.)

#### 7.2.3 Calibration Flaring

Objectives to be accomplished during flaring operations were to:

- a. Calibrate and check out instrumentation systems
- b. Acquire offsite radiological data from samples collected in the downwind trajectory of the plume
- c. Obtain rain-out data
- d. Obtain plume rise data
- e. Obtain actual concentrations of tritium and krypton-85 within the effluent plume
- f. Compare onsite instrumentation data with actual isotopic concentrations found in downwind samples

After the drill rig was removed, the EIC continuous remote monitors were deactivated or moved to different locations (e.g., the flare line).

To monitor effluent flow through the flare line, a fraction of the total gas flow was diverted, dried, and passed through a special chamber (STALLKAT) where tritium and krypton-85 were measured and the results recorded. Liquids (water and hydrocarbons) separated from the sampled gas

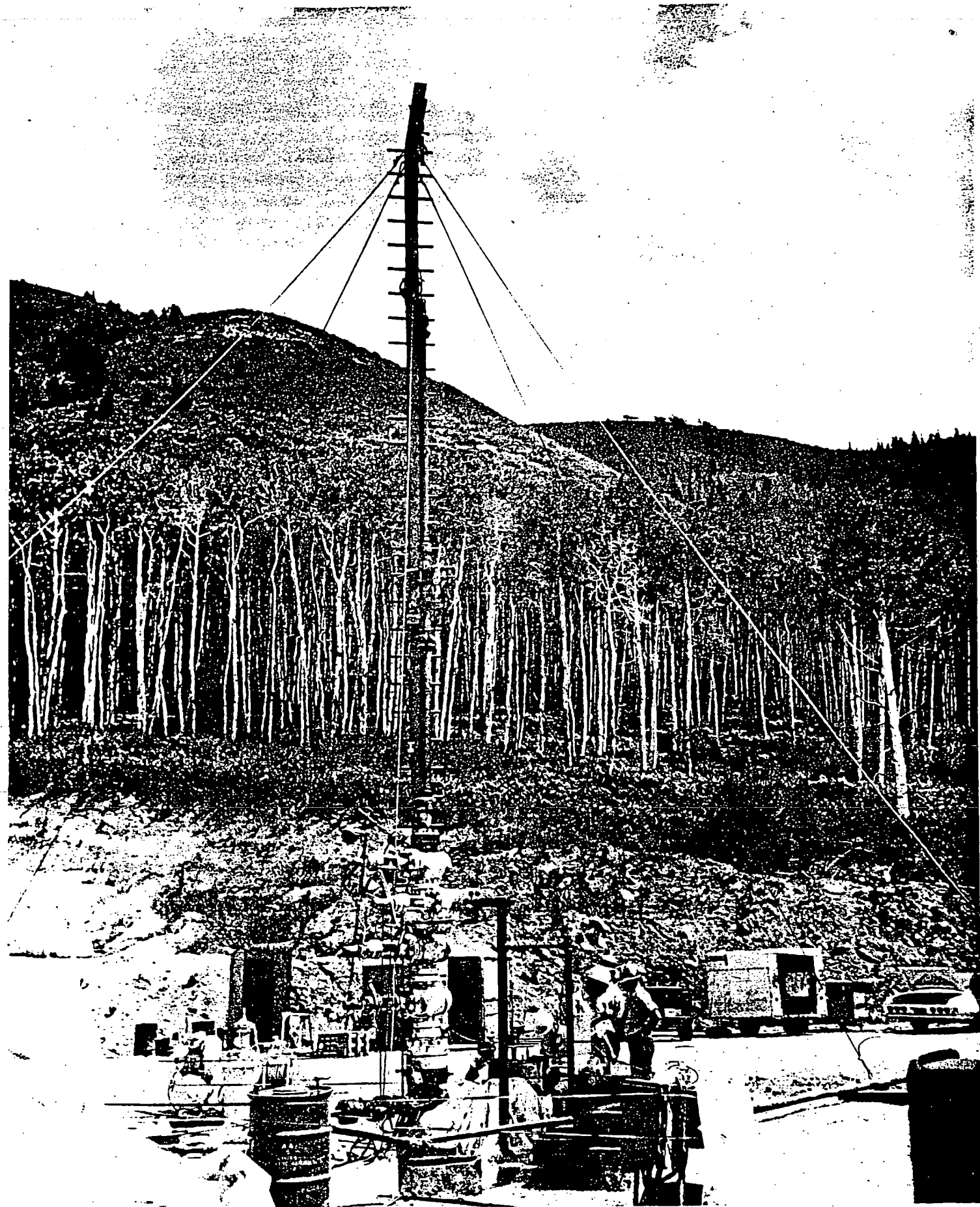


FIGURE 29. THE R-EX WELLHEAD AND ATTACHED CHRISTMAS TREE

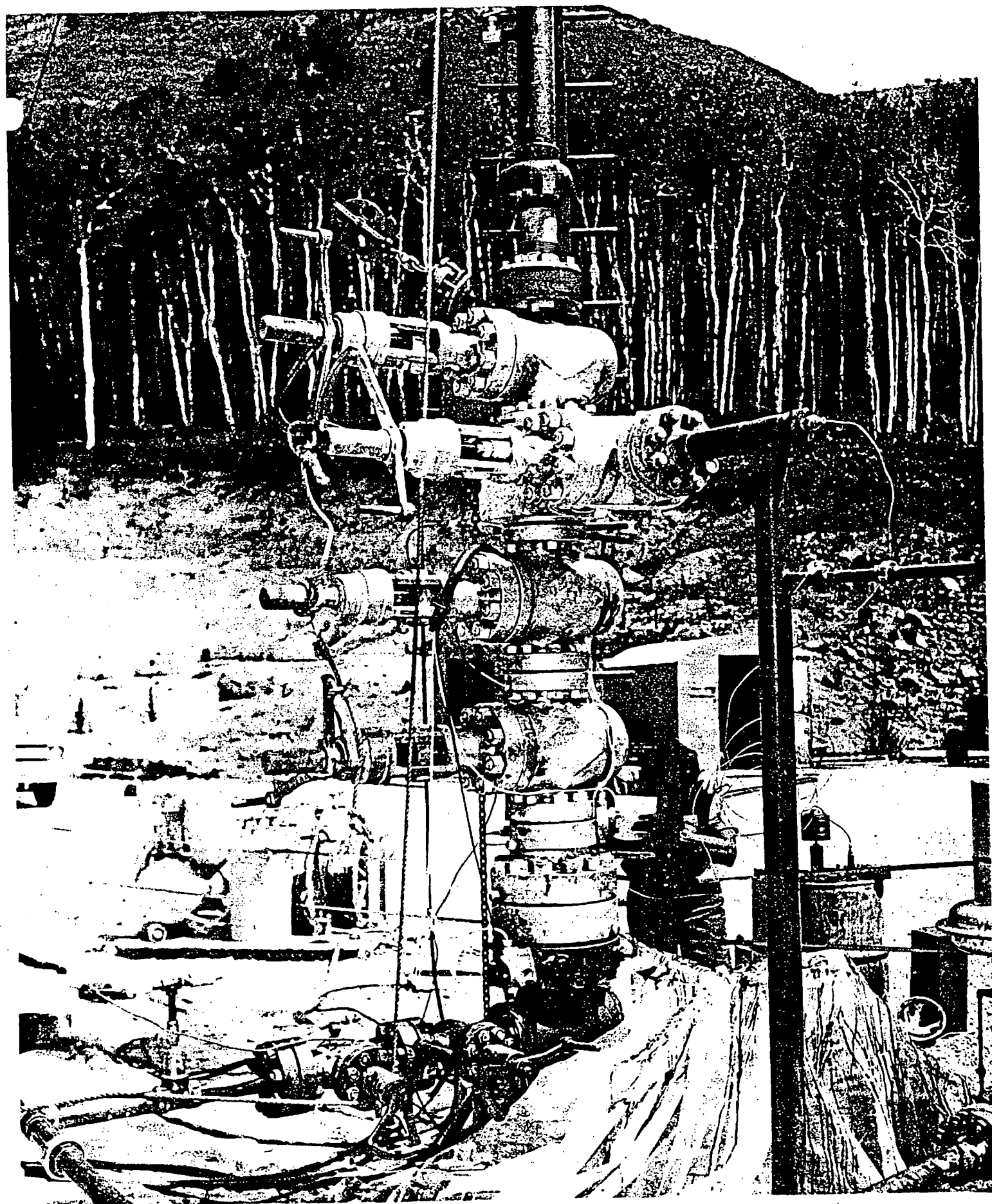


FIGURE 30. THE R-EX WELLHEAD

were analyzed for tritium and fission products to document such release in the gas going to the flare stack. The larger portion of these liquids were removed by the separator and were stored in steel tanks until analyzed for tritium, gross beta and gamma-emitters before being reinjected into the flare. A gross gamma scintillation detector was also mounted on the flare line and set to alarm if any unexpected release of fission products occurred.

The next two flaring operations were performed between October 5 and October 7, 1970, and on October 27, 1970. The first operation or test took three days and was made for the purpose of calibrating the EPA/NERC offsite surveillance program. Tracking and measurement of gaseous radioactive effluents were carefully done to confirm that the production testing program could be carried out with assurance that the health and safety of the nearby population would be protected. The volume of gas which flared during this three-day period was approximately 13 MMSCF.

During the October 1970 tests, the following meteorological conditions and flaring rates occurred: 1) an upslope drainage case while flaring at a rate of 15 MMCF per day, and 2) both an upslope drainage case and a nocturnal inversion case at a rate of 10 MMCF per day.

### 7.3 SITE ENVIRONMENTAL SURVEILLANCE

#### 7.3.1 Detonation Phase

Samples of water, soil, and vegetation were collected prior to the detonation to establish the background radiological condition of the site. Pre- and postdetonation precipitation samples were collected by USGS.

#### 7.3.2 Reentry Drilling

Samples of water, soil, and vegetation were collected prior to, during, and after completion of drilling operations. In addition, continuous air samples were collected during the drilling operations.

#### 7.3.3 Calibration Flaring and Production Testing

Samples of water, soil, and vegetation were analyzed prior to the start of flaring, during calibration flaring and periodically during and after each production test. Precipitation samples were taken during both the calibration flaring and production testing.

#### 7.4 CONTROL OF RADIOACTIVE SOURCES, MATERIALS, AND EQUIPMENT

All radioactive sources brought onsite were entered in the source control log; containers were checked for adequacy and appropriately stored. The drill rig and associated equipment were decontaminated prior to being released from the site. All equipment and material were surveyed and swiped to assure that they were below the criteria for unrestricted offsite release.

Although access control was restricted during the drilling and flaring operations, an area immediately around the drill rig was delineated and radiological control measures such as appropriate dress-out requirement and monitoring of personnel were established as part of the contamination control procedures. This same procedure was followed for certain areas such as the flare stack, decontamination pads, and the R-E area when conditions warranted it.

All waste materials with contamination levels approaching criteria were appropriately packaged and stored for disposal at the end of the project.

#### 7.5 PERSONNEL DOSIMETRY

##### 7.5.1 Detonation Phase

Film badges were issued to personnel in the initial SGZ reentry party and additional badges were available.

Urine samples were collected from ten EIC monitors prior to the detonation to establish individual background levels. None were collected after the detonation, since there was no release of radioactivity.

##### 7.5.2 Reentry Drilling, Calibration Flaring, and Production Testing

All personnel entering controlled areas at the Rulison site were issued TLDs which were evaluated on a monthly basis with a TLD reader located in the access control trailer.

A routine urine bioassay program for detection of possible tritium exposures was established during these activities. Urine specimens were collected periodically from all personnel routinely working in the site-controlled areas.

#### 7.6 INSTRUMENT MAINTENANCE

The instrument repair area provided the capability for onsite maintenance and calibration of all radiation detection instruments and measurement systems.

## 7.7 RESULTS

### 7.7.1 Detonation Phase

Monitoring and surveillance activities indicate that there was no release of radioactivity to the atmosphere as a result of the Rulison detonation.

### 7.7.2 Reentry Drilling

The original plan of reentry called for cleanout of the emplacement hole followed by drilling into the chimney. Six days following the detonation, increasing gas pressure was measured inside the Christmas Tree on the emplacement hole casing. Samples of this gas showed that it contained radioactivity. Under these conditions an explosive mixture of natural gas and gaseous radioactivity would have to be dealt with from the very onset of the operation. As a result, an alternate reentry route was chosen through the R-EX.

As previously noted in Chapter 6, the radiological monitoring systems employed during the following operational phases are summarized in Table 2. These items, except those with a d footnote, were reported daily to the Rulison Open File.

Reentry commenced on April 28, 1970. On July 26, 1970, the well began to flow and was immediately shut in and controlled by maintaining a sufficient hydrostatic head of drilling fluid to suppress the gas pressure. As operations continued, occasional small puffs of gas were released which were immediately drawn off by the exhaust ventilation system. A summary of these minor releases has been presented in Table 5, Chapter 6.

On August 1, 1970, the first major release was made when the well was test-flowed through the flare stack for 30 minutes. This release was performed to determine the reliability of the online monitoring systems for comparison with representative samples sent offsite for laboratory analysis of the chemical components and radioactivity. Onsite monitoring of the gas gave an estimated concentration of 2 to 3 pCi/cc of krypton-85. Although the onsite data for gaseous tritium (hydrogen and hydrocarbons) as measured by the STALLKAT was statistically poor, this tritium concentration was estimated to be similar to that of krypton-85. Both the krypton-85 and tritium concentrations were considerably less than the shut-down action guide values (see Appendix G). Laboratory analysis of two gas samples by Isotopes gave concentrations of 2.3 pCi/cc for both krypton-85 and gaseous tritium in the first sample and 1.8 pCi/cc for both the krypton-85 and gaseous tritium in the second sample. Radiochemical analysis was also performed by LLL at Livermore, California, and EPA/NERC at

Las Vegas, Nevada. Average concentration of the radioactive constituents reported by LLL<sup>1/</sup> (corrected for decay to time of detonation) were as follows:

<u>Isotope</u>	<u>μCi/Std cc</u>
Tritium	$1.76 \times 10^{-4}$
Krypton-85	$1.50 \times 10^{-4}$
Carbon-14	$0.14 \times 10^{-6}$
Argon-39	$1.4 \times 10^{-6}$
Argon-37	$1.07 \times 10^{-5}$
Radon-222	$0.03 \times 10^{-6}$

No particulate radioactivity resulting from the nuclear explosive was detected in the gas samples from the Rulison well.

Offsite laboratory analysis of grab samples performed by EPA, LLL, and Isotopes compared favorably with EIC online monitoring.

No further attempt to accomplish a major flow from the well was made until August 13, 1970, the day scheduled for the initial calibration flaring.

Only background levels of radioactivity were detectable on environmental samples gathered during and immediately after the reentry drilling.

### 7.7.3 Calibration Flaring

During preparation for the calibration flaring, several anomalies were observed in the behavior of the well. In the process of determining the cause of the anomalies it became necessary to intermittently flow the well for short periods (less than one hour each) during the next several days. A summary of the minor and major releases has been presented in Tables 5 and 6 of Chapter 6. As a result of these problems, calibration flaring was rescheduled for August 18, 1970.

On August 18, 1970, initial attempts were made to conduct the calibration flaring. At 11:36 a.m. MDT flaring commenced and achieved an estimated flow rate of  $17 \times 10^6$  cubic feet per day which lasted for five minutes. The flow then steadily decreased and at the end of 20 minutes an automatic safety valve shut in the well. High line pressure, caused by mud and chips plugging the separator, had activated the safety valve.

<sup>1/</sup>UCRL-50986, "Gas Analysis Results for Project Rulison Calibration Flaring Samples," C. F. Smith, January 7, 1971.

Remedial efforts were undertaken from August 18, 1970, to October 4, 1970, to remove the obstructing material from the well and system. During this period, a number of short duration releases were made while attempting to improve the well flow. On August 24, 1970, the flow from the well ceased completely and a drill rig was brought in to reestablish the well. Release data is summarized in Tables 5 and 6 in Chapter 6.

During the foregoing and subsequent flarings, there was a steady production of contaminated water and liquid hydrocarbon distillates from the separator. These were accumulated in separate holding tanks for sampling to determine the disposal method. Samples of these fluids indicated that tritium and a slight trace of absorbed krypton-85 were present and that flaring of these liquids could be performed without exceeding the release criteria. The combined radioactivity and liquids were released to the environment by injecting vaporized or atomized water or a small spray of the liquid hydrocarbons into the flare. During periods when the Rulison well was shut in, this flaring operation was carried on by using commercially available natural gas. Release activities are summarized in Table 4 of Chapter 6.

During initial injections of the water and hydrocarbon distillates, problems were encountered in adjusting a proper flow to achieve total vaporization. As a result, limited "rainout" of tritium-contaminated liquids occurred within approximately 100 feet of the stack. Also, during this period a snow storm occurred and low-level tritium activity was measured in the "snowout" within approximately 300 feet of the stack. Soil, vegetation, and snow samples gave an estimate of less than 43 mCi of tritium deposited over the affected area from these incidents.

From October 4 through 7, 1970, a well completion/calibration flaring operation was conducted. Continuous online monitoring of all releases was performed onsite in addition to periodic grab samples which were sent to three offsite laboratories. Results from these four methods continued to compare favorably. Concentrations were essentially the same as those cited earlier. Toward the end of this period, it appeared that the concentrations of krypton-85 and tritium were beginning to decline. (See Tables 5 and 6 of Chapter 6.)

With the exception of occasional downwind air samples and soil samples from known spill areas, the onsite environmental monitoring showed mainly background levels of radioactivity during and after calibration flaring. The only radioactivity found in the above background samples was tritium and the concentration was only a small fraction of the radiation concentration guide for occupational workers as given in AECM 0524.



#### 7.7.4 Production Testing

During the first production test (high-rate flaring), approximately 420 curies of krypton-85, 620 curies of tritium, 0.9 curies of carbon-14, and 0.00004 curies of mercury-203 were released to the environment. Radioactivity concentrations in the natural gas (after the separator) ranged from about 145 pCi/cc of krypton-85, 185 pCi/cc of tritium, and 0.35 pCi/cc of carbon-14 at the start of flaring to about 125 pCi/cc of krypton-85, 160 pCi/cc of tritium, and 0.30 pCi/cc of carbon-14 at the end of the test. Carbon-14, mercury-203, and part of the tritium were neutron activation products produced at the time of the nuclear detonation. Due to the presence of snow, no soil or vegetation samples were collected. However, snow samples showed tritium levels ranging from background to a maximum of 1,800 pCi/ml of moisture<sup>2</sup> in a single day's sample taken 20 yards from the flare stack after a short-term accidental extinction of the flare (as a result, a spray of tritiated water fell in the immediate area around the flare stack).

During the second production test (intermediate-rate flaring), approximately 320 curies of krypton-85, 390 curies of tritium, 0.7 curies of carbon-14, and 0.00003 curies of mercury-203 were released to the environment.

Radioactivity concentrations in the natural gas (after the separator) ranged from about 125 pCi/cc of krypton-85, 150 pCi/cc of tritium, and 0.28 pCi/cc of carbon-14 at the start of flaring to about 90 pCi/cc of krypton-85, 100 pCi/cc of tritium, and 0.23 pCi/cc of carbon-14 at the end of the test. Due to snow, no soil or vegetation samples were collected. However, tritium in snow samples ranged from background to a maximum of 5,100 pCi/ml of moisture in a single day's sample taken 20 yards from the flare stack (after a short-term rainout of tritiated water from the flare).

During the third production test (long-term flaring), approximately 270 curies of krypton-85, 1,490 curies of tritium, 0.8 curies of carbon-14, and 0.00003 curies of mercury-203 were released to the environment. Radioactivity concentrations in the natural gas (after the separator) ranged from about 80 pCi/cc of krypton-85, 90 pCi/cc of tritium, and 0.19 pCi/cc of carbon-14 at the start of flaring to about 2.8 pCi/cc of krypton-85, 3.3 pCi/cc of tritium, and 0.07 pCi/cc of carbon-14 at the end of the test. Due to snow, no soil or vegetation samples were collected during the test. However, tritium in snow samples ranged from slightly above background to a maximum of 920 pCi/ml of moisture in a sample taken 20 yards from the flare stack.

<sup>2</sup>This compares with the radioactivity concentration guide of 1,000 pCi/ml for tritium in drinking water for the general offsite population.

At no time during the entire production testing did onsite radiation surveillance detect any Rulison-related radio-activity in the environment, other than tritium. Typically, the atmospheric concentrations were less than one-millionth the tritium and krypton-85 concentrations in the gas. Thus, occupational exposures were not measurably different from background. This conclusion is supported by the results of the TLD and urine bioassay programs.

#### 7.7.5 Personnel Dosimetry

There were no personnel radiation exposures during the Rulison Project as recorded by TLD and no internal tritium exposures as indicated by the routinely scheduled urinalysis program.

#### 7.8 SITE CLEANUP

A general site cleanup was accomplished during July 1972, in accordance with guidance received from AEC/HQ.

Soil and vegetation samples were collected and analyzed to determine the distribution and concentration of residual contamination. All soil samples were below the tritium cleanup concentration guide of 30,000 pCi/g. The maximum concentration observed in soil was 20,000 pCi/g. The maximum in vegetation was 150 pCi/g (wet). No tritium above background was detected in samples of site spring water and site air moisture.

Cleanup operations resulted in two shipments of tritium-contaminated waste to the Nuclear Engineering Co., Beatty, Nevada, for disposal. The shipments consisted of 3,000 gallons of liquid containing 0.69 Ci of tritium and 33 packages of solid material estimated to be contaminated with 0.073 Ci of tritium.

Not more than 0.03 Ci of tritium were left as solidified sludge in the bottom of three (210 bbl.) liquid storage tanks. These tanks were left, anticipating use in the future production of the Rulison well. The wellhead (with present logging equipment), separator, and two (10 bbl.) hydrocarbon storage tanks which are internally contaminated with tritium were also left at the site for future production use.

Further details of the cleanup effort will be published as a separate report at a later date.

## CHAPTER VIII

### OFFSITE RADIOLOGICAL SAFETY

#### 8.1 BACKGROUND

The EPA/NERC was responsible for providing environmental surveillance to include:

- A. A determination by fixed station and mobile monitoring, and if necessary by aerial surveys, the extent of any contamination resulting from operations
- B. Maintaining a comprehensive record of public radiation monitoring data associated with the operation
- C. Ensuring continuing protection of the public health by periodic sampling of various types of environmental media, such as air, water, precipitation, milk, soil, vegetation, and animal tissues
- D. Collecting information regarding incidents which may have been attributed to the test program. (This included medical and veterinary investigations of complaints.)

Beginning with the drilling of the R-EX hole at the Rulison site in 1967, USGS, under contract with the AEC, began an extensive study of the geology and hydrology at and surrounding the site. Information was compiled pretest, posttest, and during calibration and production flaring on the physical condition of all wells, streams, springs, and R-EX encountered underground water tables in addition to data on the chemical and radiochemical constituents of the water from these sources within a radius of 10 kilometers from R-EX. Selected hydrologic studies were made within a radius of 10 to 20 kilometers of the R-EX.

Results of this entire study showed no permanent change in the physical condition of the local hydrology including no increase of the radioactive content of the water from these sources. Nine reports of this information were submitted to the Open File.

During the calibration flaring and production testing phases of the project, the LLL Biomedical Division and the Colorado Department of Health carried out independent environmental sampling programs. The data proved useful and confirmed the results of the EPA/NERC work. Personnel from the Utah State Health Department, the University of Wyoming, and Colorado state and local health departments also assisted EPA/NERC in their field activities, particularly during the detonation phase. USGS also provided useful information on radioactivity levels in streams and rivers in western Colorado.

## 8.2 RADIOLOGICAL SAFETY CRITERIA

The basic criteria for offsite radiological protection were those contained in Section II.A of the Appendix to the AEC Manual, Chapter 0524.

Guidance in preparing the operational safety plans for Project Rulison included the following criteria:

"The off-site rad-safe plans for Project Rulison will be based on the assumption that there will be no significant uncontrolled release of radioactivity off the controlled area. The controlled area will be of such a size and shape that, in the highly unlikely event there is a significant uncontrolled radioactive release, an individual located at any point beyond the boundary for two hours immediately following the onset of this postulated release would not receive a total radiation dose to the whole body in excess of 15 rem or a total radiation dose in excess of 75 rem to the thyroid from iodine exposure. These criteria are provided solely for the purpose of planning for off-site radiological safety. Their use in this respect is not intended to imply that these numbers constitute acceptable limits for emergency doses to the public under accident conditions. In the unlikely event there is a significant uncontrolled radioactive release, every reasonable effort will be made to reduce the exposure. Postevent activities for Project Rulison will be conducted under AEC MC 0524, Appendix 0524, Section 1A, Individuals in Controlled Areas, and Section II.A, Individuals and Population Groups in Uncontrolled Areas."

## 8.3 PRESHOT CULTURAL SURVEY

A detailed human population and milk cow census was taken to a distance of 25 miles from SGZ. In addition, a review of census data was conducted for an area 25 to 150 miles (a sector between 0 and 180 degrees) from SGZ. An investigation of the transient population was conducted in the Rulison area during the detonation period. Surveys also identified medical patients and handicapped residents in the area within 9 miles from SGZ.

## 8.4 COMMUNITY RELATIONS

EPA/NERC personnel made visits to officials and individuals in surrounding communities answering questions, distributing printed information, and making themselves available for any future questions.

## 8.5 MEDICAL AND VETERINARY ACTIVITIES

### 8.5.1 Detonation Phase

Prior to the detonation, veterinarians in the western Colorado and Denver areas were contacted by EPA/NERC and the Colorado Department of Health veterinarians. The basic program and project schedule were reviewed with them, and questions were answered. On D-7, an EPA/NERC veterinarian was in the Rulison offsite area with a mobile laboratory for prompt investigation of any complaints relative to livestock and wildlife following the detonation.

### 8.5.2 Postshot Activities

During the reentry drilling, calibration, and production testing phases, local veterinarians were contracted to collect periodic blood samples from locally owned sheep and cattle. The samples were used to monitor tritium levels in local domestic livestock. A veterinarian from the Colorado Department of Health also assisted occasionally with sample collection and consultation.

## 8.6 EVACUATION

### 8.6.1 Detonation Phase

Safety measures, recommended by AEC to minimize possible hazards from predicted ground motion from detonation, included the evacuation of all persons from the area within 5 miles of SGZ. Personnel evacuated from buildings within the 5-mile radius had the option of leaving the area or being a distance of two structure heights from standing objects at detonation time. (See Section 4.3 for details.)

Advice from 13 practicing physicians in Grand Junction, Rifle, and Glenwood Springs was obtained regarding evacuation procedures for sick and handicapped residents, and arrangements were made for their support in any emergencies that might arise.

EPA/NERC personnel assigned to assist in area evacuation arrived in the Rulison area several days prior to the detonation. These personnel were divided into teams with each team being responsible for evacuation within a specific area. EPA/NERC personnel contacted each resident within their areas of responsibility and explained the evacuation plan. Each day they visited every residence to keep them informed of the current status of the project.

The EPA/NERC medical officer was present in the area on D-day to supervise evacuation of invalids and to administer medical attention to residents if an emergency arose.

EPA/NERC personnel assisted in manning roadblocks at the 5-mile perimeter on D-day. To minimize the remote possibility of fire or other damage that might result from gas line or electrical wiring damage associated with ground motion, these utilities were disconnected at evacuated homes by H-2 hours. EPA/NERC personnel provided liaison for these efforts.

Prior to the detonation, EPA/NERC personnel assisted in arrangements to be certain residents of Grand Valley and Rulison were clear of structures. EPA/NERC also provided confirmation to the CP that students had been removed from schools in Grand Valley, Rulison, Rifle, and Collbran. In addition, EPA/NERC personnel provided assistance and liaison with the CP in the evacuation of the Union Carbide uranium-vanadium mill near Rifle and the USBM complex at Anvil Points.

#### 8.6.2 Reentry Drilling and Calibration Flaring

Although no radiological emergency was expected during these postshot activities, contingency plans included provisions for evacuation of residents from the Grand Valley and Morrisania Mesa areas. No evacuations were necessary, since no significant release of radioactive effluent resulted from the reentry drilling or the calibration flaring.

### 8.7 AERIAL MONITORING

#### 8.7.1 Detonation Phase

Two EPA/NERC aircraft were airborne near the R-E well at the time of detonation. The primary aircraft was equipped to conduct a radioactive cloud tracking and sampling mission while the second aircraft served as a radio relay station between the CP and EPA/NERC field personnel.

Prior to these missions, the aircraft had made several flights over the Battlement Mesa area to check for hunters or other unauthorized persons who might have entered the wilderness area near the Rulison site.

#### 8.7.2 Calibration Flaring

Since some of the major reasons for calibration flaring were centered around behavior of the resulting plume, and

actual plume concentrations and ground concentrations directly below the plume, EPA/NERC aircraft also carried out an extensive plume tracking and monitoring program.

#### 8.7.3 Production Testing

After calibration flaring, it became obvious that at flow rates in excess of 2 MMCF per day the plume rise and dispersion were so large that there was little need for any further extensive aerial efforts. However, at least once during each of the three production tests, the plume was tracked and sampled by EPA/NERC aircraft to assure the AEC there was no unsuspected plume behavior which might result in higher than expected offsite concentrations of tritium and krypton-85.

### 8.8 GROUND MONITORING

#### 8.8.1 Detonation Phase

Prior to the detonation, field personnel spent four days familiarizing themselves with the surrounding offsite area. All field personnel were equipped with supplies for collecting environmental samples, portable scintillation detectors, Geiger-Mueller survey instruments, and high-range ionization chamber rate meters, as well as portable gamma rate recorders, portable air samplers, and TLDs.

Monitors were assigned to specific areas in the proposed downwind sector and were directed to become familiar with populated locations. If a release had occurred, the monitors were prepared to take action to prevent unnecessary exposure to residents, as well as being strategically located to document cloud passage and residual radioactivity levels.

Fifteen air sampling locations in the Air Surveillance Network (ASN) were utilized. These stations were equipped to continuously sample air with particulate filters and activated charcoal cartridges. The stations were located in the following communities or areas:

De Beque	Silt	Mesa
Grand Valley	Glenwood Springs	Gunnison
Rulison	Montrose	Bond
Rifle	Carbondale	Paonia
Silt Mesa	Leadville	Collbran

Seven permanent sampling sheds were also operated at each of the following locations:

De Beque  
Grand Valley  
Morrisania Mesa (Clem and Duplice Ranches)  
Rifle (Urquhart Dairy)  
Nine miles south of Silt (Jackett Ranch)  
Four miles northeast of Collbran (Griffith Ranch)

Each of these sheds collected continuous air samples and continuously recorded gamma dose rates. They also had equipment to collect atmospheric moisture samples (molecular sieve samplers) for tritium analyses, a dehumidifier (used for rapid tritium analysis of atmospheric moisture; samples could be taken to Grand Junction for counting), and a precipitation collector. Integrating dosimeters (TLD) were also placed at each station. All sheds operated on commercial power and were periodically serviced by an EPA/NERC monitor.

Additional stations of the EPA/NERC permanent ASN located in Durango, Grand Junction, Denver, Rangely, and Pueblo, Colorado, were operated in support of Rulison. Data from other ASN stations would have been examined had a release of radioactivity occurred. The ASN consists of 103 stations throughout the western states. Air sampling results of the EPA/NERC Radiation Alert Network were also available.

Atmospheric moisture samples were collected prior to detonation at several locations in the immediate offsite area. These were collected to establish a tritium background for comparison with postshot samples.

Twenty TLD stations were established in an array in the Rulison offsite area. Each station contained three TLDs which had a detection range from 5 milliroentgen to 5,000 roentgen. The TLDs were placed in the field for three- to four-week exposure periods in April and August 1969, respectively. The dosimeters were exchanged prior to the detonation to monitor any detonation-time release of radioactivity and to document any postshot exposure levels. The TLD network was discontinued at D+8 weeks. Additional TLDs were issued to all personnel participating in EPA/NERC field operations for personnel dosimeters. Additional TLDs were available to supplement the basic network as deemed necessary.

#### 8.8.2 Reentry Drilling

During reentry drilling, EPA/NERC reactivated the 15 air sampling stations and the 7 sampling sheds.

Monitors were assigned to carry on a ground sampling program and were also prepared to immediately assist in evacuation of residents in the event of an unexpected emergency. Equipment



included portable radiation survey instruments, TLDs, environmental sampling equipment and cryogenic air samplers (for collection of tritiated water vapor). A basic counting facility was established in Grand Junction for rapid analyses of selected air and moisture samples. Environmental TLD stations were also established prior to reentry drilling and were exchanged on a monthly basis.

#### 8.8.3 Calibration Flaring

During calibration flaring, EPA/NERC continuously operated the seven sampling sheds and air sampling stations previously discussed.

EPA/NERC ground monitors also collected cryogenic (for tritium and krypton) and atmospheric moisture samples (for tritium) in the downwind areas. Positioning of ground samplers was based on both plume trajectory predictions as well as measurements made by the EPA/NERC aircraft during plume tracking and sampling missions. The most intensive ground sampling efforts in populated areas centered around Morrisania Mesa, Grand Valley, De Beque, Silt, Rifle, and Collbran.

During the initial calibration flaring, 25 specially cleared areas or sampling pads were used for downwind sample collections. The pads were located on three arcs centered on the Rulison wellhead (several hundred feet south of the flare stack) and within five miles of the site. Some pads had to be serviced by helicopter due to their remoteness.

Similar independent environmental sampling activities were conducted by LLL and the Colorado Department of Health.

#### 8.8.4 Production Testing

During the three production tests, EPA/NERC continuously operated the seven sampling sheds and air sampling stations already mentioned. However, when the results of the calibration flaring program became available, it became obvious that the predictions of potential population exposure (NVO-61) were grossly conservative. This was partly due to the fact that doses through the food pathway were based on extremely conservative assumptions and that, due to a several months delay in detonation, flaring did not occur during any crop growing seasons. In addition, preflaring estimates of atmospheric dispersion were also too conservative, hence integrated exposure predictions were too high.

The sampling sheds at De Beque and the Jackett and Griffith Ranches were shut down in March 1971, while the remaining sheds were deactivated April 26, 1971 (3 days after the R-EX well was shut in).

Similar environmental sampling activities were conducted independently by the Colorado Department of Health and LLL (first production test only). Also, EPA/NERC fielded a new gas combustion system developed for the AEC to monitor tritium in natural gas in industrial transmission lines.

## 8.9 ENVIRONMENTAL SAMPLING

### 8.9.1 Detonation Phase

A Milk Sampling Network consisting of 15 stations representing 5 grade A producers and 10 family cows was established in the Rulison area. Milk samples were collected at D-5 months, D-2 weeks, D+3 days, and D+8 weeks. If a release of radioactivity had occurred, additional samples would have been collected from this network as well as the Colorado stations of the EPA/NERC Standby Milk Surveillance Network. This standby network covers all states west of the Mississippi River.

A Water Sampling Network, consisting of 40 stations, was established representing samples from 12 municipal supplies, 6 private wells, 4 reservoirs, 4 springs, 8 streams, and 1 sample from a special USGS gauging station at Battlement Creek. Samples were collected from the network stations at D-5 months, D-2 weeks, and at D+2 months. If a release of activity had occurred, additional samples would have been collected.

Samples of natural vegetation and fruit were taken at each of 12 sampling locations during July 1969, and individual samples of native grass and sagebrush were collected from 25 locations in the potential downwind sector at D-1 week. Samples of hay and native grasses representative of milk cow feed were also collected prior to the detonation to establish background levels. Such samples established background levels of tritium and long-lived fission products resulting from worldwide fallout. No postshot vegetation samples were collected since no release of radioactivity occurred.

Beef cattle samples were collected from Grand Junction slaughter houses and from six steers from Carbondale, Silt, and De Beque, Colorado. Samples were also collected from five steers killed in late August 1969 by hunters and vehicles. Analysis was done for strontium-89 and -90 to obtain background values. No postshot livestock or wildlife samples were collected.

No soil or precipitation samples were analyzed since no release of radioactivity occurred.

#### 8.9.2 Reentry Drilling

Samples of milk, water, precipitation, vegetation, soil, milk cow feed, domestic animals, and wildlife were collected by EPA/NERC prior to the start of drilling. EPA/NERC was prepared to collect additional samples had an unexpected release of radioactivity occurred.

A similar sampling effort was conducted independently by the Colorado Department of Health, with environmental sample types limited to precipitation and water samples, and milk samples. These samples were collected from over most of western Colorado.

#### 8.9.3 Calibration Flaring

Samples of milk, water, precipitation, vegetation, soil, milk cow feed, domestic animals, and wildlife were collected by EPA/NERC before and after the calibration flaring.

A similar (though geographically more extensive) independent sampling effort was conducted by the Colorado Department of Health. Environmental sample types were limited to precipitation, water, and milk.

The LLL Biomedical Division also independently conducted an extensive environmental sampling program, which (in addition to atmospheric moisture) was limited to vegetation, water, milk, and precipitation samples.

#### 8.9.4 Production Testing

During the first production test, the environmental sampling activities were approximately the same as during calibration flaring. During the remainder of the testing, the LLL Biomedical Division declined to participate further because of the extremely limited amount of positive information being derived from their work (i.e., essentially all offsite samples were background).

Following the third (and final) production test, EPA/NERC analyzed all sample types normally collected and in addition collected samples of local crops for human consumption (cherries, etc.) during the late summer and early fall period. EPA/NERC and the Colorado Department of Health continue to sample water from the Rulison area for tritium.

## 8.10 NATURAL GAS SAMPLING

Prior to the Project Rulison detonation, natural gas samples were collected from three existing wells within seven miles of the experimental well. These wells were considered to be producing gas from the gas-bearing formation in the detonation area. Also, following the detonation, gas samples were again collected from one of the wells two days after the event. The only radioactivity detected in the samples was the naturally occurring radionuclide radon-222 and its daughter products. The concentrations of radon-222 in all samples ranged from 26 to 45 picocuries/liter (pCi/l) of gas. No apparent change in concentration occurred following the detonation.

Postshot natural gas samples were collected from the test well during preparations for the calibration flarings, during the calibrating flarings, and during production testing. The radionuclides and the ranges of their concentrations detected in the samples were as follows: 1) argon-37, 750-5,000 pCi/l gas; 2) argon-39, 1,100-4,600 pCi/l gas; 3) carbon-14, 270-570 pCi/l gas; 4) radon-222, 12-24 pCi/l gas; 5) tritium, 10,000-330,000 pCi/l gas; and 6) krypton-85, 11,000-300,000 pCi/l gas. No radionuclides in the form of particulates were detected in the samples except for a small amount of mercury-203, which could not be quantitated.

## 8.11 RESULTS

### 8.11.1 Detonation Phase and Reentry Drilling

No fresh fission products attributable to Project Rulison were found in any of the air, water, milk and feed, soil, vegetation, animal, precipitation, or natural gas samples analyzed.

The TLDs and film badges in the surveillance network and those worn by project personnel showed no positive exposures. No radiation levels greater than background were detected by monitors in the offsite area following the detonation.

### 8.11.2 Calibration Flaring

Flaring at 2 MMCF per day on October 4, 1970, during down-slope (nocturnal) air flow was monitored by the LLL Biomedical Division. Of the numerous samples collected, only four atmospheric moisture (tritium) samples were significantly above background: 1) 50 pCi/m<sup>3</sup> on Morrisania Mesa and 2) 12 pCi/m<sup>3</sup>, 46 pCi/m<sup>3</sup>, and 170 pCi/m<sup>3</sup> on Holmes Mesa.<sup>1</sup>

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<sup>1</sup>Radioactivity Concentration Guides in air for the general offsite population were 67,000 pCi/m<sup>3</sup> for tritium and 100,000 pCi/m<sup>3</sup> for krypton-85.

EPA/NERC sampling at a flow rate of 8 MMCF per day under downslope (nocturnal) air flow on October 5, 1970, failed to detect any offsite levels significantly in excess of background.

Flaring at 10 MMCF per day on October 5, 1970, during downslope (nocturnal) air flow was also monitored by the LLL Biomedical Division. Of the numerous samples collected, none were significantly above background. During flaring of 10 and 15 MMCF per day on October 5 under upslope air flow, EPA/NERC samples indicated tritium levels in the offsite area ranging from background ( $5\text{--}10\text{ pCi/m}^3$ ) to a maximum of  $290\text{ pCi/m}^3$  at a sampling pad about 0.5 miles from the flare stack. Krypton-85 concentrations in the plume ranged from  $17\text{ pCi/m}^3$  (about 40 percent above the background of  $12\text{ pCi/m}^3$ ) to a maximum of  $150\text{ pCi/m}^3$ . Concentrations of tritium and krypton-85 were considerably lower in the populated areas. The LLL offsite samples collected during the upslope air flow were all within the range of background.

All the Colorado Department of Health samples were within the range of background.

#### 8.11.3 Production Testing

During the first production test, EPA/NERC atmospheric samples (tritium) from offsite areas were within the range of background to a net maximum of  $27\text{ pCi/m}^3$ . Aircraft samples from the plume showed maximum net tritium concentrations of  $72\text{ pCi/m}^3$  (October 28, 1970) and maximum net krypton-85 concentrations of  $145\text{ pCi/m}^3$  (October 27, 1970). Concentrations in the populated offsite areas were generally much lower. All other EPA/NERC offsite samples were background except for a few soil and vegetation samples collected within a few thousand feet of the flare stack which may have been slightly above background.

The LLL Biomedical Division personnel participated only during the first production test. Their data showed offsite atmospheric samples (tritium) from populated areas ranged from background to a maximum of  $27\text{ pCi/m}^3$ . All other offsite environmental samples were background except one snow sample (net of  $5\text{ pCi/ml}$  of tritium)<sup>2</sup> collected about a thousand feet from the flare stack (very near the onsite boundary).

During the second production test, EPA/NERC atmospheric samples (tritium) ranged from background to a net maximum

<sup>2</sup>The Concentration Guides for tritium in drinking water was  $1,000\text{ pCi/ml}$  for the general offsite population.

of 34 pCi/m<sup>3</sup> while krypton-85 ranged from background to net maximum of 17 pCi/m<sup>3</sup>. Aircraft samples from the plume showed a maximum net tritium concentration of 32 pCi/m<sup>3</sup> and a maximum net krypton-85 concentration of 42 pCi/m<sup>3</sup> (both on December 8, 1970).

During the third production test, EPA/NERC's atmospheric samples (tritium) ranged from background to a net maximum of 23 pCi/m<sup>3</sup>, while krypton-85 ranged from about 40 percent above background to a net maximum of 15 pCi/m<sup>3</sup>. Both maximum samples were collected at the old CP pad (2.5 miles from the flare stack). Concentrations in populated offsite areas were considerably lower.

All atmospheric (tritium) and environmental samples collected by the Colorado Department of Health during the first and second production tests were background except one atmospheric moisture sample (December 2, 1970). This sample contained a gross tritium concentration of 28 pCi/m<sup>3</sup>. All atmospheric and environmental samples collected during the third production test by the Colorado Department of Health were within the normal background range.

While USGS had no official role in offsite radiological surveillance, it conducted a fairly extensive stream and river monitoring program throughout western Colorado. No radioactivity was observed which could be attributed to Project Rulison.

## CHAPTER IX

### METEOROLOGICAL SUPPORT

#### 9.1 OBJECTIVES

The Rulison experiment was designed and conducted to prevent uncontrolled release of radioactive products to the surface. However, as a precaution, the detonation was planned to take place only when the winds were directed into a sector which satisfied the requirements specified in the Operations Safety Plan. This sector was delineated by DONO.

The objectives of the ARL-LV program of weather predictions and radioactivity estimates were to:

- A. Provide and interpret climatological data and estimated downwind radioactivity concentrations required by the various participants during the preshot planning and preparation phase.
- B. Provide weather and air trajectory forecasts and estimates of potential downwind radioactivity concentrations to the DONO and his advisory panel during the detonation.
- C. Document meteorological conditions in the vicinity of the Rulison site subsequent to the time of detonation, and provide postshot analyses and reports consistent with experimental results.
- D. Provide meteorological support as required by DONO or his representative during the postshot reentry and production evaluation program.

#### 9.2 OPERATIONS

Four surface wind towers, located near the project site, provided automatic measurements of surface wind speed and direction which were radio-telemetered to a master station in the weather trailer at the CP. A 24-hour weather observing station, equipped to make upper air soundings of wind, temperature, humidity, and pressure and surface observations, was operated in the CP area for 15 days preceding the detonation. Local and national network meteorological data and forecasts were available at the NOAA/Air Resources Field Research Office at Walker Field in Grand Junction.

Operation-oriented forecasts of winds, weather, vertical atmospheric stability, and air trajectories were presented to DONO and his advisory panel in daily formal and informal briefings beginning at D-7 days. Estimates of potential downwind radioactivity concentrations, in the unlikely event of a release of radioactivity into the atmosphere, were also presented at each briefing.

Intensive surveillance of changing meteorological conditions at the surface and aloft was maintained on D-day. Hourly surface and pilot balloon observations were taken at the CP, at three locations near the Rulison site, and at Grand Junction. The DONO and his advisory panel were kept informed of the meteorological situation starting with the morning readiness briefing in Grand Junction and continuing at the CP throughout the day.

D-day meteorological data were such that winds would have transported any released radioactivity in the predicted direction.

The onsite weather observing station and weather forecast office were reestablished during the postshot reentry period to provide around-the-clock forecasts and documentation of meteorological parameters at the surface and aloft.

During calibration flaring, forecasts of vertical wind and stability parameters were provided to DONO. Upper wind and temperature soundings were made onsite, and winds aloft were measured at three offsite locations to provide meteorological data for correlation with radiation data.

Two surface wind instruments were provided near the wellhead for use by EIC personnel during long-term production testing.



## CHAPTER X

### INDUSTRIAL SAFETY

#### GENERAL

The NV industrial safety requirements were included in the overall program. There were no serious injuries, accidents, or damage to government equipment. The onsite industrial safety program was carried out satisfactorily. Basically, the plan was implemented in the following manner:

#### 10.1 MEDICAL SUPPORT

A trained first-aid man was available, complete with first-aid supplies, communications, ambulance, and a small trailer with a bed, at the R-E well area during all potentially hazardous operations. The aid man was employed through the Clagett Memorial Hospital at Rifle, Colorado, and had access to immediate communications with staff physicians.

#### 10.2 SITE SAFETY

The operation involved limited quantities of heavy equipment and only a few small areas of user facilities. Consequently, the potential for serious accidents was limited. The access road to the project area, though steep and narrow, was well maintained and had adequate turnouts. Approximately 12 new vehicles were inspected and kept in good condition. Housekeeping (site orderliness) was good.

#### 10.3 FIRE PROTECTION

Onsite fire protection was provided by an adequate number of suitable fire extinguishers and fire barrels. Backup volunteer fire fighting services from Grand Valley, about eight miles from the project site, had also been arranged. Adequate spacing was provided for all trailers and structures. The areas of use had been well cleared of undergrowth for adequate distances.

#### 10.4 SANITATION

Drinking water was supplied in clean, cool cans and was competently handled. Toilet facilities were of the portable type and were clean and sanitary.

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# CHAPTER XI

## COSTS

This chapter contains tabulations of costs incurred in relation to Project Rulison. Table 7 shows the AEC/NV funded execution costs. Table 8 tabulates reentry costs and Table 9 relates total execution and reentry costs. Table 10 shows reimbursable work billed to Austral/CER.

TABLE 7.--AEC/NV-Funded Execution Costs for Project Rulison

Participant	FY 1969	FY 1970	FY 1971	FY 1972	Total
EG&G	\$ ---	\$ 18,056.53	\$ ---	\$ ---	\$ 18,056.53
ERC	---	1,300.00	---	---	1,300.00
F&S	---	842.40	---	---	842.40
GAB	---	133,684.86	25,962.24	3,907.92	163,555.02
H&N-OCTD	413.62	2,171.99	---	---	2,585.61
JAB	---	29,967.00	5,199.00	---	35,166.00
NV Direct & Misc.	---	1,840.31	---	---	1,840.31
REEC0	14,409.88	4,879.42	---	---	19,289.30
U of Nevada	---	283.96	---	---	283.96
USGS	---	3,000.00	---	---	3,000.00
WES	---	1,350.00	---	---	1,350.00
Total	\$14,823.50	\$197,376.47	\$31,161.24	\$3,907.92	\$247,269.13

TABLE 8.--AEC/NV-Funded Reentry Costs for Project Rulison

Participant	FY 1970	FY 1971	FY 1972	FY 1973 <sup>1/</sup>	Total
BMI	\$ 22,135.67	\$ ---	\$ ---	\$ ---	\$ 22,135.67
EIC	2,841.23	1,577.42	5,986.62	41.96	10,447.23
EPA	82,872.00	211,018.00	5,935.00	---	299,825.00
F&S	3,851.03	---	---	---	3,851.03
H&N-OCTD	7,200.00	---	---	---	7,200.00
Isotopes	6,215.85	---	---	---	6,215.85
NOAA/ARL	5,000.00	---	---	---	5,000.00
NV Direct	---	---	170.50	---	170.50
REECo	26,216.27	49,784.39	218.43	---	76,219.09
U of Nevada	---	4,227.27	---	---	4,227.27
USBM	---	1,099.42	---	---	1,099.42
USGS	9,682.08	9,127.57	(1.06)	---	18,808.59
Total	\$166,014.13	\$276,834.07	\$12,309.49	\$41.96	\$455,199.65

<sup>1/</sup> As of January 31, 1973

TABLE 9.--Total Project Rulison Execution and Reentry Costs Funded by AEC/NV

Participant	FY 1969	FY 1970	FY 1971	FY 1972	FY 1973 <sup>1/</sup>	Total
BMI	\$ ---	\$ 22,135.67	\$ ---	\$ ---	\$ ---	\$ 22,135.67
EG&G	---	18,056.53	---	---	---	18,056.53
EIC	---	2,841.23	1,577.42	5,986.62	41.96	10,447.23
EPA	---	82,872.00	211,018.00	5,935.00	---	299,825.00
ERC	---	1,300.00	---	---	---	1,300.00
F&S	---	4,693.43	---	---	---	4,693.43
GAB	---	133,684.86	25,962.24	3,907.92	---	163,555.02
H&N-OCTD	413.62	9,371.99	---	---	---	9,785.61
Isotopes	---	6,215.85	---	---	---	6,215.85
JAB	---	29,967.00	5,199.00	---	---	35,166.00
NOAA/ARL	---	5,000.00	---	---	---	5,000.00
NV Direct & Misc.	---	1,840.31	---	170.50	---	2,010.81
REECo	14,409.88	31,095.69	49,784.39	218.43	---	95,508.39
U of Nevada	---	283.96	4,227.27	---	---	4,511.23
USBM	---	---	1,099.42	---	---	1,099.42
USGS	---	12,682.08	9,127.57	(1.06)	---	21,808.59
WES	---	1,350.00	---	---	---	1,350.00
Total	\$14,823.50	\$363,390.60	\$307,995.31	\$16,217.41	\$41.96	\$702,468.78

<sup>1/</sup> As of January 31, 1973

TABLE 10.--Project Rulison Reimbursable Work Billed to Austral/CER

Phase	Participant	FY 1969	FY 1970	FY 1971	FY 1972	FY 1973 <sup>1/</sup>	Total
Execution	BMI	\$ 6,596.86	\$ 637.96	\$ ---	\$ ---	\$ ---	\$ 7,234.82
	EIC	9,453.48	29,262.38	---	---	---	38,715.86
	EPA	27,960.00	74,979.00	---	---	---	102,939.00
	ERC	9,864.74	16,650.00	---	---	---	26,514.74
	GAB	---	10,000.00	---	---	---	10,000.00
	Isotopes	5,972.41	2,606.89	---	---	---	8,579.30
	JAB	89,997.00	53,996.00	---	---	---	143,993.00
	NOAA/ARL	1,628.75	33,549.94	---	---	---	35,178.69
	NOAA/ESL	16,375.98	24,580.18	---	---	---	40,956.16
	REECo	26,733.47	8,397.25	---	---	---	35,130.72
	USBM	1,200.00	33,800.00	(353.34)	---	---	34,646.66
	USGS	14,994.55	17,800.00	---	---	---	32,794.55
	WSI	2,220.34	32,020.51	---	---	---	34,240.85
Reentry	EIC	---	178,856.69	416,348.72	1,236.21	15,539.51	611,981.13
	NOAA/ARL	---	26,500.00	35,885.13	---	---	62,385.13
Total		\$212,997.58	\$543,636.80	\$451,880.51	\$1,236.21	\$15,539.51	\$1,225,290.61

<sup>1/</sup> As of January 31, 1973

## CHAPTER XII

### CLASSIFICATION AND SECURITY

#### 12.1 CLASSIFICATION

The position of Classification Advisor of Project Rulison was filled on a continuous basis by the NV Classification Officer.

Basic classification guidance for Project Rulison was in accordance with the Classification Guide for the Peaceful Application of Nuclear Explosives (CG-PNE-1) as supplemented by the Project Rulison Classification Guide, dated April 11, 1969. An unclassified version of the guide was also prepared and distributed for general use.

There were no major classification problems involved in connection with Project Rulison.

#### 12.2 SECURITY

##### 12.2.1 Organization and Mission

NV was responsible for all facets of the security program. AEC security interest consisted of receipting, handling, storing, transmitting, and safeguarding documents and material classified up to and including Secret/Restricted Data (SRD), including a complete nuclear explosive. The original operational security program was activated on April 24, 1969, and due to project rescheduling, was terminated on May 7, 1969. The final operational security program was activated on August 6 and terminated on September 13, 1969.

During the security operational phase, WSI furnished armed guards for the Rulison site security interests and for local movement of classified matter. Security areas were established at the wellhead building compound, the emplacement well and locked box, and the arming and firing trailer. Materials and documents classified up to and including SRD were authorized in these locations on an as-required basis.

The "Buddy System," or two-man concept, was utilized for protection of the nuclear explosive upon arrival and until detonation.

The OCC and security trailers, located in the CP, were established as limited security areas where storage and/or work with Confidential/Restricted Data documents was authorized when and as required. During normal nonoperating hours, all classified matter was secured in containers approved by Security, and guard coverage was extended for security as well as plant protection and safety functions.

Other security services provided by WSI included escorting of classified matter at the site; motor patrols to assist in security safeguards, emergency plans, property protection, and relief for security stations; and areas of security interest. In compliance with, and in conjunction with, DONO's Schedule of Events and Operations Plan, the guard force also performed aerial and ground sweeps over mountainous and wooded terrain and established roadblocks and muster controls for clearing areas for operational functions and for the detonation area on D-day. The guard force was augmented during area sweeps, screening operations, and roadblock controls with members of the Colorado Highway Patrol, the Garfield County Sheriff's Office and Posse, and the Mesa County Sheriff's Office. This augmentation, from operational and economic viewpoints, was successful. Members of the Garfield County Sheriff's Office and Posse were utilized in screening operations at the CP for several days prior to D-day. Due to detonation postponements, their private commitments required their replacement by members of the guard force.

Security-approved, permanent-type, chain link fencing was utilized to surround the wellhead compound security area. Temporary barriers of barbed wire and/or nylon rope were used to designate other security and controlled area boundaries. Area boundaries were supplemented with fixed point security protection afforded by a combination of administrative controls including signs, interior and exterior floodlighting during hours of darkness, 24-hour guard control of access at points of entry/exit, and frequent interior/exterior patrols. Storage containers and/or sight barriers shielded classified objects and operations from observation by uncleared and unauthorized personnel in contiguous areas.

Armed escort service was provided for the movement of classified matter between the site and local offices of the U.S. Postal Department. Such matter was received at, or dispatched from Grand Junction or Rifle, Colorado, via registered mail.

#### 12.2.2 Shipment and Explosive Movement

The movement of the explosive to the site was the responsibility of the Manager, ALO. NV accepted custody of the explosive and associated components at the site from ALO couriers. The shipment was accomplished utilizing courier-operated, specially equipped government vans. Final assembly of the explosive was accomplished under "Buddy System" controls in the Wellhead Building in the fenced exclusion area.

SS Nuclear Material Accountability Facility NAD at NTS maintained the accountability of SS material used in the project and prepared the necessary certificate of expenditure.



### 12.2.3 Site Access Control

#### a. Detonation Phase

Prior to detonation, all radiation areas were controlled by barriers, signs, and radiation monitors. Full Anti-C clothing, respiratory protection, and dosimetric devices were available for use by reentry parties if required. EIC monitors participated in initial SGZ reentry operations. Additional monitors were in standby status if needed. Other EIC personnel were involved in reading and relaying the RAMS data. The RAMS surveillance and routine radiation surveys of the SGZ area were continued through September 13, 1969.

#### b. Reentry Drilling, Calibration Flaring, and Production Testing

Personnel access to the Rulison reentry site (R-EX pad) was controlled through an EIC-staffed and -maintained access control trailer. The facility provided for routine issuance of personnel dosimeters, logging personnel in and out of the R-EX area, maintaining a daily operations log, and issuing radiological equipment and clothing. In addition, the trailer provided storage for first-aid equipment, was the location of the liquid waste storage tanks alarm readout panel and the site telephone and radio, since the trailer was continuously occupied (secondary alarms and associated strip charts were located in the radiological measurements trailer).

Within the R-EX site fence, additional radiological exclusion areas were established as needed (e.g., around the base of the flare stack and around the decontamination pad adjacent to the R-EX wellhead).

### 12.2.4 Postshot Security Interest and Controls

The only classified interest remaining at the Rulison site is the underground radioactive debris in the chimney. This debris is classified SRD until analyzed and is protected by approximately 8,000 feet of overburden. A security plan for postdetonation operations was published detailing controls for the period from detonation to chimney entry.

### 12.2.5 Clearances and Identification Officer

Clearance information was processed by NV using various agencies' certification forms, Badge Request Forms, or Form AEC-277. Security clearance information stated on the form was verified for access to Defense Information, or certified for access to Restricted Data, as applicable

through the requester's normal AEC or Department of Defense channel prior to the form being accepted as authority for issuance of identification media.

#### 12.2.6 Intelligence

Prior to deployment of security forces to Project Rulison, arrangements were made with the Operations Office of Region IV, 113th Military Intelligence Group located in Denver, to provide Chief, Security, with any intelligence information that would have a bearing on the project. After arriving at the site in early August 1969, communication channels were established for all federal, state, and local law enforcement agencies in addition to the Military Intelligence Group in order to effect timely receipt of information concerning dissident group activities aimed at disrupting, delaying, or canceling the test.

Close liaison with intelligence and law enforcement agencies was maintained throughout the operational phase of the project which resulted in numerous reports of proposed adverse action. DONO was promptly apprised of these reports as they were received, and numerous joint meetings were held in Grand Junction, Glenwood Springs, and the Rulison site to coordinate these reports and to plan appropriate countermeasures.

The complete cooperation of the concerned Colorado law enforcement agencies and the 113th Military Intelligence Group in connection with providing DONO and his staff with pertinent, concise, and timely information, as well as the execution of planned countermeasures, contributed in a large degree to the successful execution of Project Rulison.

## CHAPTER XIII

### PUBLIC INFORMATION ACTIVITIES

#### 13.1 INTRODUCTION

The NV Office of Information Services (OIS) and CER began detailed public affairs planning early in January 1969. One of the first public actions was announcement of the start of contract negotiations between the government and Austral/CER on February 6, 1969. During this period, NV drafted and coordinated the Rulison Fact Book which was completed and approved when the Rulison contract signing was announced on March 26, 1969. After the contract was signed, NV had authority to implement the detailed public information and public affairs plan, which called for full coordination of all new information announcements and actions among all the project participants. Generally, NV was the planning and initiating agency. NV made arrangements for a series of public meetings and briefings in Colorado by using the contacts developed through CER's prior efforts.

#### 13.2 PUBLIC BRIEFINGS

Teams composed of representatives from NV, USBM, LASL, USGS, EPA/NERC, Austral, and the Colorado Department of Health conducted briefings at Grand Junction, Grand Valley, Rifle, Glenwood Springs, and Meeker using CER-established contacts to arrange the meetings. The meetings were open to the public and had unlimited question and answer sessions. These briefings, held in April, and CER's initial contacts, apparently were largely responsible for local support and cooperation accorded the project.

#### 13.3 STATE OFFICIALS

CER's initial contacts with Governor Love's office and members of his administration were a factor in establishing good communications between the state government and AEC. The Governor was briefed directly several times, but day-to-day communication was achieved through the state's liaison officer for Rulison, the Director of the Colorado Department of Natural Resources. This communication enabled NV to respond quickly to the information needs of the Governor and his officers.

#### 13.4 PROJECT OPPOSITION

Opposition to the project became apparent in late April 1969. The Colorado Committee for Environmental Information wrote an open letter to the Colorado legislature calling for a moratorium on nuclear explosions "in our state until such time as the reassurances of the Atomic Energy Commission can be supported by factual evidence and the objective consideration thereof by independent analysis." The Committee later sought information about the project from several sources, including NV and EPA/NERC.

Demands for information from these groups reached a peak when the Committee submitted an extensive list of questions about the project to NV, EPA/NERC, and the industrial sponsors. One major point the committee repeatedly made to news media was that it could not get replies to its questions. The difficulty in replying to the questions was several fold: 1) the answers often involved classified material, 2) many of the questions required a considerable amount of research and coordination by and among several agencies, and 3) manpower was committed directly to the execution of Rulison or other projects. Nevertheless, NV compiled responses to the Committee's questions, but their delivery to the Committee was withheld when legal counsel advised against delivering the answers while a court suit seeking an injunction against Rulison was being heard. The replies to the Committee's questions were delivered to the organization's president immediately after the litigation was resolved, and they were made available to the public through the Rulison open file established at the Denver Federal Center.

### 13.5 JOINT OFFICE OF INFORMATION

The Joint Office of Information, staffed by project participants from the time it opened in Grand Valley on August 10, 1969, generally functioned well in handling news media requests and visits to the site. It was handicapped by two factors: 1) the court suit in Denver, which required the services of key personnel and 2) the unfamiliarity of some of the personnel with the project and the effects of underground testing.

### 13.6 POSTSHOT ACTIVITIES

Prior to reentry, the public affairs program for the project was kept minimal, largely because of advice from legal counsel not to engage in public activities that might affect the court suit then in progress, in which the plaintiffs sought an injunction to prohibit postshot flaring. This legal admonition was reinforced when the U.S. District Judge warned the counsel not to try the case in the newspapers.

Only three information or public affairs actions were taken in this period, which were: 1) providing background information and interpretation of technical data to the press during recent periods of the trial in Denver in January, 2) notifying the press of and accompanying them through the Rulison gas sampling procedure in early January 1970, and 3) conducting a limited public opinion survey in the Rulison area, primarily regarding damage claims settlements. The survey conducted in early February 1970 showed some resistance to possible future detonations in the Rulison area, primarily because of uncertainty regarding seismic shocks destroying property, and partially because some persons felt there would be no economic benefit to them.

Following the court case, there was little concern expressed about the flaring program. The principal concern was with potential property damage from future detonations. A "Public Affairs Plan for Rulison after Trial Decision" was prepared by NV and submitted to the Division of Public Information, AEC/Headquarters. The plan proposed action to inform public opinion leaders in Rulison area communities about postshot plans.

AEC representatives visited Grand Junction and vicinity March 26, 1970, to learn the feeling of the local inhabitants regarding the Rulison postshot effort and to discuss the AEC public relations efforts. The Mayor of Grand Valley indicated that there was little concern about postshot activities, and the Mayor of Rifle suggested that public meetings not be held at that time. The visit resulted in an opinion that people in the Rulison area were quiet about the post-shot program and were looking forward to the results.

The Rifle City Water Department included a questionnaire regarding another nuclear stimulation project similar to Rulison in every fourth water bill for April 1970. Of 250 questionnaires sent, 188 were returned. Survey results show that 59 percent of Rifle residents favored nuclear gas stimulation, 29 percent did not want another nuclear detonation, and 19 percent gave conditional approval of additional nuclear stimulation projects if they are proved safe.

On May 6, 1970, a public officials briefing was conducted at the Grand Valley School auditorium by NV, Austral, and the Colorado Department of Health representatives. The purpose was to inform public officials of what to expect in the reentry flaring operations. The public officials in attendance appeared to support or at least not oppose the project. About 50 local area officials attended. After the briefing, officials were conducted on a tour of the Rulison site to observe reentry operations. On May 7, 1970, a local residents' briefing was conducted at the Grand Valley School for the same purpose, but a site tour was not conducted. About 40 people attended. Many were not from the Grand Valley area. Local area residents appeared to support the project; however, some of the outsiders were openly opposed to Project Rulison.

OIS/NV issued two Rulison news releases in July 1970 (see Appendix D). One on July 29, 1970 (Release NV-70-76), reported that the fractured zone had been penetrated, and one on July 31, 1970 (Release NV-70-79), said that it was planned to flare "something more than 50 thousand cubic feet of natural gas in the next few days to obtain samples of gas for detailed radiochemical analysis."

In August 1970, OIS/NV issued Rulison news releases (see Appendix D) relating to: 1) plans for flaring small amounts of gas to obtain representative samples of the gas in the chimney prior to calibration flaring, 2) samples of gas taken for analyses, results of which showed average concentrations of tritium and krypton-85 well below protective action guidelines for the project, 3) the opening of the AEC's claims office in Grand Valley on August 31, 1970, and 4) proposed remedial work to the reentry hole.

A news release stating that flaring was tentatively scheduled to resume about October 3, 1970, was issued October 1, 1970 (Release NV-70-101). A press conference was conducted October 27 for Colorado news media at the Rulison site. In general, the press was very receptive to all information presented. Reporters' questions were reasonable and relevant.

A press release was issued November 30, 1970 (Release NV-70-119), which reported that Rulison production test flaring was scheduled to be resumed December 1, 1970.

A press release issued December 29, 1970 (Release NV-70-131), reported that the second production test flaring was completed December 20, 1970, and that the third production test was scheduled to begin in four to six weeks.

A press release issued January 29, 1971 (Release NV-71-7), said that the third production test was scheduled to begin February 2, 1971. On February 3 and 4, 1971, a CBS-TV news team visited the site. Austral's Miles Reynolds and AEC's A. Dean Thornbrough were interviewed.

A press release issued April 12, 1971 (Release NV-71-22), said that radioactivity of the gas being flared had decreased to 1/20 of the level present at the first calibration flaring in October 1970, and that the gas was being analyzed by ORNL, LLL, and Isotopes.

A press release issued April 23, 1971 (Release NV-71-25), reported that Rulison flaring had ended, and that an estimated total of 455 MMCF of gas has been flared since the well was reentered on August 1, 1970.

A press report on May 17, 1971 (Release NV-71-30), said that a small leak had been found on the Rulison control head. Some 50,000 cubic feet of gas was flared while the leak was repaired.

### 13.7 TECHNICAL INFORMATION PLAN

Refer to Appendix E.

CHAPTER XIV  
RULISON LITIGATIONS

14.1 COSCC/C-1712

On August 2, 1969, Civil Action C-1712, entitled "Colorado Open Space Coordinating Council" on behalf of "all those entitled to the protection of their health and safety, and the health and safety of those generations yet unborn, from the hazards of ionizing radiation resulting from the distribution of radioactive materials through the permanent biogeochemical cycles of the biosphere as a result of the defendants conduct of Project Rulison, and on behalf of all those entitled to the full benefit, use and enjoyment of the national natural resource treasures of the state of Colorado without degradation resulting from contamination with radioactive materials released as a result of the defendants conduct of Project Rulison, and all others similarly situated, Plaintiffs, vs Dr. Glenn T. Seaborg, Chairman of the Atomic Energy Commission, Austral Oil Company, Incorporated, and CER Geonuclear Corporation, Defendants." Also included in the caption of the Complaint were: "U.S. Atomic Energy Commission, Bureau of Mines, U.S. Department of Interior, and Los Alamos Scientific Laboratory, as their several interests may appear" (hereinafter "COSCC" or C-1712).

14.2 CROWTHER/C-1702

On August 22, 1969, Civil Action C-1702, entitled "Richard L. Crowther, Willard Eames, Charles Morgan Smith, individually and as Parent and Next Friend of James Hopkins Smith, III, and James Hopkins Smith, III, on behalf of themselves and all persons similarly situated, Plaintiffs, vs Dr. Glenn T. Seaborg, Chairman of the Atomic Energy Commission, Austral Oil Company, and CER Geonuclear Corporation, Defendants" (hereinafter "Crowther" or C-1702) was filed in the U.S. District Court in Denver, Colorado.

14.3 DECISION

The complaints sought, among other things, an injunction to prevent the detonation of the Rulison explosive and an injunction to prevent the flaring of the gas and the release of radioactivity to the atmosphere. Various legal propositions were advanced to support the requested injunction. The two complaints were consolidated and heard on Motion for Summary Judgment and Motion to Dismiss filed by the Department of Justice on behalf of the Dr. Seaborg and by the corporate defendants, before Judge Arraj on August 26 and 27, 1969. On August 27, 1969, Judge Arraj denied the plaintiff request for injunction to prevent the detonation; the court retained jurisdiction on the request to prevent subsequent flaring and specified that defendants could not flare the gas within six months after the first detonation without first coming into the court to be heard. Defendants had stipulated there would

be no reentry operations until six months after detonation. The court's comments on safety are noteworthy:

" . . . I am impressed with the fact that the government has up to this point exercised extreme caution and care to protect the persons, the animal life, the plant life, the water supply and other things that may be adversely affected by the detonation of this device." (DR. of Decision, pp. 8-9)

#### 14.4 APPEAL

Plaintiffs immediately appealed the denial to the U.S. Court of Appeals, Tenth Circuit (Cases numbered 448-69 and 449-69). On September 2, 1969, Circuit Judge Hill, speaking for the three-judge emergency panel which had heard the appeal, sustained Judge Arraj's denial of the request for injunction and denied the original application for injunctive relief filed in the Circuit Court with the appeals. The Circuit Court, while stating that "From the limited nature of the order appealed from and the relief originally requested here, we do not propose to go into the merits of the litigation . . .," did note:

"After carefully considering the evidence adduced by appellants (plaintiffs) in support of injunctive relief, we must conclude that they have presented a very weak case. It is totally lacking in support of the necessary ingredient of irreparable damages. Such damages, under the undisputed evidence, is very remote, and not within the realm of probability. As they have in connection with the many other underground nuclear explosions detonated in the past, the Atomic Energy Commission and the other cooperating governmental agencies are exercising the highest degree of care, caution and expertise to prevent any possible damage to life, property and natural resources. The trial judge's findings of fact are clear, comprehensive and fully supported by the evidence." (Decision, pp. 5-6)

Plaintiffs' efforts to secure a Writ of Certiorari were unsuccessful.

#### 14.5 DUMONT/CIVIL ACTION 6563/C1722

On August 29, 1969, Martin G. Dumont, District Attorney for Garfield County, brought suit against CER-Austral in the State Court (Martin G. Dumont, District Attorney for Ninth Judicial District vs Claude Hayward, Austral Oil Company and CER Geonuclear Corporation, Civil Action 6563) to prevent the detonation of the Rulison explosive. The AEC was not named party to the suit.

CER/Austral removed the case to the U.S. District Court under diversity of citizenship, alleging the joinder of Claude V. Hayward was an effort to divest the Federal Court of jurisdiction.



The District Court, Judge Arraj, sustained the removal (Civil 1722) and based on the prior decisions in the Crowther case (Civil 1702 and Civil 1712), denied the requests for injunction against the Rulison detonation on September 3, 1969. Plaintiffs' appeal to the Circuit Court resulted in that court sustaining Judge Arraj's decision on September 4, 1970.

#### 14.6 POSTSHOT TRIAL

Subsequent to the Courts' decision to permit the detonation on September 4, 1969 (postponed for weather reasons until September 10, 1969), plaintiffs undertook extensive discovery depositions of various AEC-AEC contractor personnel and Austral personnel prior to commencement of the trial before Judge Arraj on January 2, 1970, in which all cases were consolidated; during the trial, which lasted through January 16, 1970, 22 witnesses testified on behalf of the several parties and scores of exhibits were submitted to the court.

On March 16, 1970, Judge Arraj handed down his decision which permitted AEC-Austral to reenter the Rulison chimney and undertake the flaring program set forth in NVO-61, entitled "Project Rulison Post-Shot Plans and Evaluations," subject to the AEC providing the Court, on a timely basis, copies of "raw data" which were to be furnished to the AEC open files in Denver, Colorado, Bartlesville, Oklahoma, and Las Vegas, Nevada, and to the Colorado Public Health Department. Further, the court retained jurisdiction:

" . . . for the purposes of assuring that further activities in connection with this phase of the Rulison Project will be carried out in accordance with the plans as approved by the Court, and for such other and further action as may be deemed appropriate in the premises."

The court discussed each of the major issues raised by the parties. A short summary of selected major issues follows:

- A. Members of the public, including associations of people, have standing to bring suit against the AEC where they allege threat to their health and safety.
- B. The action of the AEC in approving the Rulison contract constituted an agency "action" within the meaning of the Administrative Procedures Act so as to subject the Rulison operations to judicial review; the Court also held its general equitable jurisdiction permitted such review.
- C. The AEC safety programs satisfied the Congressional mandate to the AEC to carry out AEC's program so as to protect health and to minimize danger to life and property:

" . . . we find that the ultimate issue of fact must be resolved in favor of the defendants. The proposed flaring of gas from the Rulison cavity has not been shown to present a danger to life, health or property of the plaintiffs, or any others similarly situated."

- D. There was no "credibility gap"--AEC carried out its detonation program as AEC had stated it would. The court stated:

"We find no evidence of an AEC credibility gap, and no evidence that the AEC cannot be relied upon to implement its plans for the Rulison flaring within the standards it has established and published."

- E. The AEC radiation standards are adequate to protect life, health and property:

"The defendants have provided substantial evidence to support the validity of the standards as currently established, and the plaintiffs have not met their burden. We, therefore, find that the plaintiffs have failed to establish that the FRC and AEC radiation protection standards are not reasonably adequate to protect life, health and safety."

- F. There was no basis to sustain plaintiffs' contention that the radiation standards be immediately reduced 10 times, for example, the 0.17 rem per year standard be reduced to 0.017 rem per year:

"However, although the plaintiffs did introduce impressive evidence of new developments in the field of radiation biology, they failed to prove that these developments show the necessity of lowering the standards. The failure of proof has two elements . First, they did not establish an adequate correlation between this information and radiation exposure at low dose levels. Second, they did not refute equally new and impressive evidence of repair of the biological damage from radiation at low dose rates and levels. . . . Thus, although the plaintiffs claim that their demand for a lowering of the standards is supported by "hard evidence" of radiation effects at or below the low dose levels of the radiation protection standards . . . We find that the evidence of repair provides support for the theories of threshold and practical threshold and has not been controverted."

Neither party appealed the decision.

## CHAPTER XV

### PRIVATE PROPERTY DAMAGE COMPLAINTS

#### 15.1 CLAIMS OFFICE

The Project Rulison Claims Office was opened at 143 First Street, Grand Valley, Colorado, immediately following the detonation. This office, under the direction of the AEC/NV Claims Officer, was established to receive and process property damage complaints and/or claims attributable to ground motion arising from the detonation.

#### 15.2 INVESTIGATION PROCEDURE

Damage complaints were investigated by GAB claims adjusters and JAB seismic response engineers. Use of mobile radios increased the daily number of complaint investigations accomplished by each engineer and/or adjuster by providing a means for damage complaints reported to the claims office by telephone, mail, or in person, to be relayed to the field promptly, affording a means for the adjusters in the field to contact the JAB seismic response engineers to arrange for an engineering investigation of those complaints for damage where credibility of the damage required verification; and providing a means of giving other instructions to adjusters or engineers in the field.

#### 15.3 AEC INVESTIGATIONS AND REPAIRS

Although detailed plans had been made to replace any window glass broken, and to accomplish other types of damage repairs of an emergency nature through the service of a Grand Junction general contractor, it became apparent soon after detonation that there were no local contractors available to assist claimants in preparing estimates of damage as a basis for filing their claims. By direction, GAB hired a Grand Junction building contractor to provide estimates of repair for project-caused damage. This contractor provided repair estimates which were in fact guaranteed repair bids for which his firm would do the repair work. These estimates served to establish a basis for repair costs in settlement of credible property damage claims occasioned by ground motion from the detonation. The majority of claimants accepted the estimates as fair and reasonable but preferred to do their own repairs. Those claimants who desired to have the repairs made by the contractor who prepared the estimate were given to understand that any arrangements for such repair were strictly between themselves and the contractor. (See Table 1 for types of damage complaints.)

Prior to detonation, plans were laid to reduce the GAB adjuster staff when the volume of complaints and/or claims (estimated at 400) decreased to a level capable of being handled by a lesser number of adjusters. A target date was also set for closing the

Grand Valley Claims Office with only one adjuster working out of the Grand Junction GAB office to handle those few sporadic complaints anticipated. The receipt of complaints dropped substantially during the five weeks following the detonation, and accordingly, one claims adjuster was released from assignment on October 15, 1969, and a target date of October 30, 1969, for closing of the Claims Office was established. The number of complaints and/or claims received had reached a total figure of 326 by mid-October 1969, and of 191 formal claims, 162 claimants had been paid \$34,278.10 total.

The complaint and claims office remained open until November 14, 1969. The closing was publicly announced on October 28, 1969, along with the information that any complaints and/or claims would be accepted at the GAB office at 1010 North Fifth Street in Grand Junction. This announcement in the local newspapers and by local radio and television stations further stated that investigative reports of complaints and/or claims would be forwarded to the Technical Support Division, NV, by the GAB Grand Junction office. Following the announcement, a flurry of complaints were received by the Grand Valley Claims Office.

On November 7, 1969, the second adjuster of the original complement was released from the project assignment, and a week later the Claims Office was closed and the third and fourth adjusters released from assignment. The fifth adjuster, who was on loan from the Grand Junction GAB office, returned there, taking the remaining 49 open Project Rulison complaints and/or claims files for further processing. The total number of complaints and/or claims received had reached 362 at the time of the closing of the Grand Valley Claims Office. Of that total number, 255 formal claims had been filed, of which number 232 had been processed for payment in the amount of \$50,928.09 total. The majority of property damage complaints and/or claims were received from Grand Valley, Rifle, and Collbran and their surrounding rural areas. The lowest amount paid in settlement of a property damage claim was in the amount of \$7.50 for damaged gas heater elements, while \$4,795.16 for pump damage and loss of production at the Rifle Union Carbide Plant was the highest amount paid for damage attributable to ground motion from the detonation.

During the 15 weeks following the closing of the Claims Office in Grand Valley, only 32 complaints and/or claims were received for processing. Of the 394 complaints and/or claims received, 275 formal claims were filed, of which 261 were processed and paid in the total amount of \$69,777.29 by NV under the provisions of Section 167 of the Atomic Energy Act.

#### 15.4 ASSISTANCE TO AUSTRAL

In early November 1969, NV was requested by Austral to have GAB investigate on a reimbursable basis those damage complaints and/or claims which Austral had received. A meeting was held at NV on November 18, 1969, with representatives of Austral, CER, GAB, and NV to establish the mechanics for handling those claims they had

received for preshot coal mine shutdowns and interrupted big game hunting trips, some of which were, in part, a responsibility of the AEC for settlement. Negotiations for settlement of 17 claims were recommended by GAB and payment was effected by Austral. Of the 17 claims, AEC/NV participated in two claim settlements for Rulison-caused damage. The highest amount paid by Austral in settlement of a claim was \$17,304.48 for shutdown and loss of production of a coal mine. The lowest claim paid by Austral was \$124.50 for nonresident hunter's interrupted hunting trip. These amounts were in settlement of claims which were originally presented in the amounts of \$39,750 and \$500, respectively.

#### 15.5 CONTINUING ACTION

Complaints and claims continued to be received through the anniversary date of the detonation. Preshot, the total number was anticipated to be in excess of 425 and the total cost to the government in settlement of these claims was estimated to be about \$200,000.

The Project Rulison Claims Office was reopened at its original location in Grand Valley, Colorado, on August 31, 1970, for the receipt of claims from those individuals who were waiting until the deadline of one year approached. Prior to reopening the Grand Valley Claims Office, a total of 419 complaints had been filed, of which number 307 had been formalized as claims; a total of 286 claims had been processed for payment in the amount of \$81,814 and one Rifle, Colorado, claim had been forwarded to the Congress with a recommendation for payment in the amount of \$16,335.64; 12 claims had been formally denied by AEC/NV; and 8 claims were under investigation, pending settlement.

At the close of the anniversary date of September 10, 1970, a total of 458 complaints of damage had been filed resulting from the Project Rulison detonation. Formal claims numbering 358 were received, and at the time of closing the Grand Valley Claims Office on September 30, 1970, a total of 319 claims had been processed for payment in the amount of \$93,831.45; 1 claim previously referenced had been referred to Congress for payment; 18 claims had been denied and/or were pending denial; and 20 claims were under investigation.

By June 30, 1971, all investigations of claimed damage to those claims under investigation had been completed and settlements had been accomplished in all but three instances. (These three outstanding claims may be honored upon request to NV by the claimants involved and the outstanding dollar figure for the three claims is \$511.24.) By August 31, 1971, a total number of 322 claims had been paid in the total amount of \$109,907.29 (including payment of a Rifle, Colorado, claim for \$16,335.64 authorized by the Congress); a second claim over the \$5,000 limitation was found to be meritorious and had been recommended for payment in the amount of \$7,717.35 to Headquarters for Congressional action; three claims as stated above are pending payment upon application of the claimants; 31 claims have been denied by letter from AEC/NV based upon investigative findings.

A Rifle claimant whose claim had been denied after several investigations appealed through his attorneys to have his claim reopened. Further investigation was accomplished with no change noted in the basis for honoring this \$67,510 claim, and on January 6, 1972, it was again denied. The claimant filed suit on July 12, 1972, in Federal Court, Denver, Colorado. The litigation was settled and compromised by the Department of Justice for \$10,000.

Excluding settlement costs of the two claims referred to Congress for a recommended settlement of \$24,052.99 (both of which have been paid), the AEC/NV has incurred costs of approximately \$220,000 in the investigation of 458 complaints and claims and settlement of 323 claims arising from the detonation of Project Rulison. Table 11 shows the amount of property damage by location. Some minor costs continue for the reinvestigation of occasional appeals of denied claims and for the investigation of late filed complaints which might be processed under the Price-Anderson legislation.

TABLE 11.--Project Rulison Property Damage  
Complaints and/or Claims

LOCATION	COMPLAINTS/CLAIMS	CLAIMS PAID	AMOUNTS
Grand Valley	188	166	\$ 41,050
Rifle	141	110	70,966
Collbran	33	19	9,632
Silt	13	13	1,843
Cameo	1	1	3,405
DeBeque	16	7	3,495
Other	67	8	1,232
TOTALS	459	324	\$131,623

## CHAPTER XVI

### CONCLUSIONS AND RECOMMENDATIONS

#### 16.1 GENERAL

This joint effort by the government and private industry resulted in a successful project which may lead to development of vast supplies of gas in low permeable areas. This is extremely important since the nation's present supply is decreasing rapidly.

The government's experience in nuclear testing covers several decades with assistance from private interests. This chapter contains comments, conclusions, and recommendations from both the government and its industrial partners.

#### 16.2 PLANNING AND PROCEDURES

##### 16.2.1 Conclusions

The Project Rulison definition procedure was satisfactory; however, more detailed planning would be desirable to facilitate cost and damage estimates and to make available more factual information. The procedure lacked comprehensive postshot plans, but it was agreed that the Rulison Technical Committee would base their plans on results from the detonation.

Austral/CER used NV contractors to field safety-related programs. These contractors presented difficulties to Austral/CER during project planning. Even though numerous meetings were held between the contractors and Austral/CER, the contractors stated that they were not consulted enough on planning preparations.

Difficulties were encountered in the overall effects planning and in inventorying structures, mines, water wells, and springs in the Rulison area. These difficulties could be corrected by the recently modified procedure for planning Flowshare industrial projects. The main problem to be corrected by this modified procedure involves the time available to conduct preliminary and final analysis and make predictions about hazards involved with detonation.

The inaccuracy of preshot surveys became evident when a structure was overlooked because the individual(s) cataloging facilities failed to ask the owner if any other structures existed. A complete list, with cross-references, of several facilities was not available to organizations involved in this project. Consequently, when an owner of a facility was contacted by project groups, or when he contacted the CP, the Joint Office of Information, or

Austral/CER regarding a facility, the facility was revisited. This required extra effort over that originally programmed by USGS and JAB.

Ground motion measurements proved that ground motion predictions were accurate.

Project Rulison effects evaluation studies provided most of the information used to develop the operations and safety plans. These studies made possible the implementation of all area control programs.

#### 16.2.2 Recommendations

Future project definitions should contain an effects evaluation and detailed plans. These plans are needed to: 1) identify and prepare accurate cost estimates, 2) estimate potential damage and to take appropriate protective measures, and 3) have factual information for use in drafting environmental impact statements for briefings and forums. Also, project definitions should contain detailed postshot plans. These plans are needed prior to contract negotiations to explain project objectives, potential environmental impacts, methods and safeguards, and to better understand potential postshot funding requirements.

Difficulties that occurred during the NV contractor safety-related programs could be overcome by having the sponsor arrange for safety-related tasks to be performed by private contractors. In this matter, the sponsor would have a more positive role in program planning and implementation while the NV would retain control through reviews and inspections.

The accuracy of preshot surveys could be improved by:

- a. Requesting that project contractors make a checklist which would include questions about the surveyed location and items pertaining to this location.
- b. Making a cross-reference listing showing each survey location which would be furnished to EPA/NERC, the Joint Office of Information, the industrial sponsor, and the OCC. This would prevent redundant surveys and improve public relations with the local inhabitants. By providing detailed cross-referenced information, the above organizations can answer each individual query in a way to minimize duplicating survey effort.
- c. Shot time coordination procedures should also be developed by the project contractors and by the AEC Office of Effects Evaluation Effects Officer.



### 16.3 NUCLEAR EXPLOSIVE SAFETY

#### 16.3.1 Conclusion

From a safety standpoint, the Rulison project was successful.

#### 16.3.2 Recommendations

Future Plowshare projects should use the same general nuclear explosive safety guidances as were used in Project Rulison.

### 16.4 ENGINEERING AND LOGISTICAL SUPPORT

#### 16.4.1 Conclusions

NV and NV contractor personnel suggested construction program changes which satisfied the AEC safety standards. These changes involved additional logging for cement bond and density verification, exact distance from boron sleeve to hole bottom, drying case, and drill collar modification for mandril runs.

#### 16.4.2 Recommendations

Before any of the planning work is accomplished, an "agreed-to" project schedule should be made.

Project drawings and specifications for future projects should be more detailed.

### 16.5 COMMUNICATIONS

It was concluded that the engineering of communications equipment and the planning of services was inadequate in that it did not provide the system required by DONO. The single module radio network was also inadequate due to being overloaded by 80 mobile units plus aircraft and fixed stations.

The CCTV equipment overheated and the very high frequency and ultra high frequency units for aircraft and helicopters were not reliable. In addition, adequate lead times were not available for obtaining frequencies and for planning and installing air-to-ground stations.

### 16.6 RADIOLOGICAL SAFETY

#### 16.6.1 Conclusions

Plans, procedures, and equipment prepared to ensure on-site and offsite radiological safety were generally effective in providing the desired results. Though there were measurable releases of radioactivity and minor

contamination problems, they were within the safety guidelines and/or controlled effectively by the contractors responsible, such that no measurable exposure occurred to either onsite workers or offsite populations.

Extreme difficulty was experienced with water separation in the gas flare line. The resulting accumulation of water caused freezing of the sampling systems during periods of high gas flow and/or low ambient temperatures.

Much effort was expended in attempting to comply with changing radiation control criteria relating to the decontamination of material, ground contamination, and low level waste disposal. These criteria were related to satisfying the more stringent guidance relating to environmental considerations rather than to satisfying established health and safety criteria for onsite workers.

An extensive radiological sampling and analysis program was conducted. Documentation was made of a variety of situations, many of which contributed little to radiological health and safety evaluation. It was not until the period of long-term production flaring began that a radiological health program, commensurate with the evaluated problems was used.

The radioactive contaminated water handling and disposal system was improperly designed and inadequately controlled to meet the varying conditions encountered during production testing.

The use of the PDP8/L Computer at Rulison was not optimized. Although the computer was originally envisioned as a committed on-line device, necessary to produce "raw data" in time for the open file reporting requirements, it was only used to produce the open file format with all data input being done manually. The machine was useful in first step data reduction, but this type of information was not required by the open file.

All methods used to measure krypton proved reproducible and reliable.

Nearly all operational radiological problems were associated with remedial work.

#### 16.6.2 Recommendations

The STALLKAT should not be used for monitoring tritium. Tritium release should be calculated strictly on the basis of periodic whole gas sampling and be related to continuous krypton measurements.

By controlling fluids through the use of drip pans, decontamination and large waste accumulations can be accomplished easier.

Future projects of this nature should have separated gas drying and sampling systems that are independent of the conventional gas processing systems.

An analysis should be made of radiation criteria required for health and safety of onsite workers vis-a-vis the radiation which is permissible for release to the environment and controlling radiation criteria should be established which will provide adequate guidance for the timely development of instrumentation and techniques to meet anticipated problems (i.e., decontamination of material, low level waste disposal, and allowable ground contamination).

An evaluation should be made of each Plowshare project to determine the probable hazards which require full instrumentation and evaluation and those improbable occurrences which should be instrumented with alarms only, until they develop.

Radiation safety personnel should be included in the planning and engineering of any future contaminated water handling and disposal system.

Handling and disposal of contaminated water should be totally under the control of radiation safety personnel.

## 16.7 METEOROLOGY

Extensive arrangements were in effect before and during the detonation to provide and interpret climatological data and estimates of downwind radioactivity concentrations. The meteorological data at the time of the detonation were such that the winds would have transported any released radioactivity in the predicted direction.

## 16.8 INDUSTRIAL SAFETY AND HEALTH

### 16.8.1 Conclusion

The industrial safety, health and fire protection was satisfactory; i.e., vehicles, site orderliness, medical services and provisions for fire protection, and sanitation. Some difficulty was experienced because the respective responsibilities of the participants was not specifically understood.

16.8.2 Recommendations

Future AEC/Industrial partner arrangements should clearly define responsibilities and interfaces in this aspect.

16.9 SECURITY

16.9.1 Conclusions

Security and safety were improved by employing aircraft and helicopters for surveillance. In particular, helicopters were very effective in watching areas that were inaccessible by four-wheel drive vehicles.

Protestors camping in nearby mountains concerned security, particularly with respect to the 2 1/2 miles of arming and firing cables which ran from the CP to SGZ.

The security forces, in conjunction with state and county law enforcement personnel, conducted aerial and ground sweeps and established roadblocks and muster controls for clearing areas.

The dual ledger system proved satisfactory, and it was economical.

The AEC security measures for safeguarding classified documents and materials up to SRD, including the complete nuclear device, were effective. No major problem occurred.

Arrangements made between the AEC and military intelligence agencies and with federal, state, and local law enforcement agencies to receive information concerning dissident group activities were effective. Additionally, planned countermeasures to anticipated adverse actions were effectively executed.

16.9.2 Recommendations

In addition to security-approved fencing for security areas, firmly established outer perimeter barriers posted with warning signs should be erected around or at centers of extensive activity.

Emplacement holes or ground zero operations should not be in close proximity to public thoroughfares.

16.10 PUBLIC INFORMATION

16.10.1 Conclusions

Early contact by CER with state and local civic and business leaders paved the way for NV's subsequent meetings, and

meetings with state and local officials. The majority of state officials and residents of the areas most directly affected by Project Rulison became supporters of the project.

A limited postshot public opinion survey was conducted in the Rulison area by NV in response to rumors of complaints regarding damage claim settlements. It was found that most complaints stemmed from the same few people. A subsequent Rifle City Commission survey showed 29 percent of the people were against additional nuclear detonations, primarily because of ground motion and the lack of demonstrated economic benefits to its residents. Fifty-nine percent favored nuclear development of natural resources. Nineteen percent favored development if it could prove safe.

#### 16.10.2 Recommendations

Conservation and antipollution groups may have opposed Project Rulison regardless of whether or not project participants had been able to respond to their demands for instant information and briefings. Nevertheless, some members of these organizations probably would respond favorably to timely information, provided the presentation was nontechnical and comprehensible to the layman. Accordingly, whenever opposition to a project appears, a briefing should be arranged for that group as soon as possible.

Community surveys should be conducted periodically after the detonation to determine what public information and community affairs actions should be taken, if any, to respond to the needs and concerns of the affected communities.

Future Plowshare projects should provide for the presence of newsmen, including television, in the CP at shot time. If they cannot be permitted in the CP for lack of room or any publicly justifiable reason, they should be housed in the CP compound and given CCTV views of SGZ with direct commentary from the CP. This would remove much of the mystery and fear from nuclear detonations.

#### 16.11 LITIGATIONS

Three separate injunctions were sought to prevent the Rulison detonation and also to prevent flaring operations and the release of radioactivity to the atmosphere. The court(s) denied the injunctions to prevent the detonation and retained jurisdiction on the request to prevent flaring.

A postshot trial was conducted. The decision reached, which permitted Austral to reenter the cavity and start the flaring program, is explained in "Project Rulison Post-Shot Plans and Evaluations" (NVO-61). The U.S. District Court in Denver, Colorado, continues to retain jurisdiction to assure that further Project Rulison activities will be carried out in accordance with approved plans.

## 16.12 PROPERTY DAMAGE

### 16.12.1 Conclusions

The AEC/NV arrangements for receipt of damage complaints and/or claims were well publicized. The complaints were investigated and adjusted payments were promptly made. Originally, it was estimated that approximately 425 complaints would be received and that the total cost to the government would approximate \$200,000 for repair of property damaged resulting from Project Rulison ground motion. The amount actually paid for claims settlement, including two claims forwarded to Congress for legislative action, was less than \$132,000. See Table 11.

The AEC assisted Austral in processing several claims received by that company, one of which involved joint responsibility, another was a responsibility of the AEC. All claims were duly settled.

### 16.12.2 Recommendations

Increased participation, if not complete funding of the investigation and settlement of property damage complaints, and/or claims by the Industrial Participant is recommended for future Plowshare projects. Most desirable would be the participation of the insurance industry through availability of insurance coverage to Industrial Participants for property damage and personal liability coverage.

## 16.13 AUSTRAL

### 16.13.1 Conclusions

The Project Rulison detonation was carried out successfully and with almost uncanny precision in the predictions of ground motion and by-product radioactivity resulting from it.

Although a successful technical achievement was attained, the total cost more than doubled the best original estimates. Since the outset of Project Rulison, funding of all the technical programs was dependent on the industry partner. The nuclear explosive and the systems necessary to

fire it were to be funded by the AEC. To get the necessary preliminary safety studies started prior to execution of the contract, it was necessary for Austral to advance funds to the AEC.

Project Rulison, the second in the gas stimulation applications, was indeed a step forward using a larger yield device, buried deeper, utilizing a different emplacement technique under supervision of LASL.

The establishment of OPNE was well received by industry. The united experience with OPNE was a step in the right direction.

#### 16.13.2 Recommendations

When Austral had to advance funds for preliminary safety studies to the AEC, this is when Austral realized that they would have no control over these costs or in fact over any of the safety-related costs of the project. Although the government may require full latitude wherein safety matters are concerned, industry should not have to sustain the unlimited exposure to cost as was the case in Project Rulison. It is important for the future that industry be able to negotiate the limits of their financial liability.

Interaction with the AEC and the laboratory revealed the need for petroleum operations oriented personnel within the AEC or laboratory structure. This would provide better communication with industry and eliminate unnecessary misunderstandings, particularly in the area of safety reviews and requirements.

The Plowshare program has developed thus far through a NV nuclear weapons oriented office. This fact alone presents a host of problems to industry. Industrial projects should be developed outside the weapons testing framework.

One segment which needs to be developed outside the framework of the weapons testing program is the use of non-government contractors. While their use was a necessity to get Project Rulison done within a reasonable length of time, it is essential for the future that the AEC assist industry in developing an expertise outside the government contractor sphere. Greatest assistance can be given by providing whatever information can be made available to all potential services contractors. It is essential that further declassification of information be developed to facilitate this transition.

16.14 CER

16.14.1 Conclusions

In general, Project Rulison went quite well. The project went better than expected and many areas of doubt concerning technical and administrative functions and participant interactions were resolved.

The division of responsibility between participants was hazy. Each participant was working to satisfy his own program needs with varying objectives in addition to the technical aspects of the program.

Better use should be made of government equipment and contractors for future events. During Project Rulison, certain types of equipment were in short supply and, at times, it appeared that equipment from other projects might have to be withdrawn for use at Rulison. The lack of capability and information needed to perform tasks or calculations compelled the industrial participant to use government subcontractors. This was regrettable since those paying the bills under the arrangement had no input or influence with those who generated the costs. A more serious consequence resulted from the difficulties involved in the free interchange of technical information. The problem associated with delay of dissemination of project information until it had been approved up and down the line is self-evident.

Much of the procured space in the Rifle office was wasted. This central office should have been located in Grand Valley or Grand Junction.

The use of the "maximum credible" accident model for Project Rulison was unfortunate. Instead, one should impute a degree of confidence to the depth of burial and stemming and take appropriate safety measures for the balance of the risk. The repeated public assurances that nothing was going to vent was totally offset when the operation was based on the assumption of substantial venting.

Costs could have been cut if a more suitable site was chosen. For example, the CCTV system would not have been required if the CP was in line of sight of SGZ. Another example was the road leading to the site. It was built on such steep grades that much of the heavy equipment required power assistance. This was particularly true during the winter when a large portion of the working day was lost when both equipment and personnel tried to get to their work locations.



During Project Rulison, roadblocks were a problem because of the unnecessary inconvenience to travelers on the main roads and also to the local inhabitants. For Project Rulison, about 42 roadblocks were implemented with several additional or standby roadblocks to be activated on command by DONO. Thirty-six roadblocks were activated at H-1 1/2 hours, H-1 hour, and a few at H-45 minutes. The duration of the roadblocks depended upon the length of closed road and the time it took to inspect the road for possible postshot rockfalls. There were six roadblocks used to isolate the Morrisania Mesa area. These were activated at H-4 hours and were lifted at D+6 hours. These roadblocks were maintained as a safety measure to keep people out of the area. The duration of these roadblocks resulted in confusion and bad feeling among the local people who wanted to return to their homes.

Initially, the evacuation of mines was considered for a limited radius with one exception, that being the Dutch Creek Mine which is regarded as being very gaseous. Because the Sommerset Mines were near the Dutch Creek Mine, it was considered politically expedient to include those mines in the evacuation list. Unfortunately, this evacuation involved 200 men on a 3-shift basis. The United Mine Workers maintained that no shift could be treated differently than any other, so all three shifts remained off on D-day.

First order surveys of Battlement and Harvey Gap Dams were made; additional seismic stations were developed and homes, mud pits, mines, and wells (pre- and postshot condition) were documented prior to detonation. This was done to eliminate, disprove, or reduce postshot damage claims.

#### 16.14.2 Recommendations

Better communication is needed for future experiments which can deal with participant differences. It was clear that various planning or contract documents could not sufficiently bridge this gap. Routine scheduled meetings between the participants might possibly bridge this gap. These meetings should be limited to personnel who actually have commitment authority to deal with future problems.

The contract documents should establish broad areas of responsibility and a modus operandi. The Rulison contracts allowed some areas of confusion and doubt as to responsibility and authority. The written division of responsibility in the contract contained so much detail that it caused misunderstanding over items which were covered or stated explicitly. Obviously, enough detail

can never be generated to cover all possible items, and one way to designate the division of responsibility is with broad categorization. The net result is that better joint plans must be developed to reduce the deviation to those that are necessary or desirable and which can be jointly agreed upon. This requires that those with operational responsibility and authority within the government and industrial organizations participate early in the planning stages and become committed to the plans. As technology advances toward commercial application, performance criteria should be developed by the government and a review system be established which will certify industry's compliance.

Government guidelines for industry need to be developed. The government has not provided satisfactory guidelines permitting industry to develop a project without constant consultation with the government. Examples of areas needing guidelines are in well drilling, communications, containment, and safety standards.

Increased effort should be made in technical communication with the technical community. An informed technical community might counterbalance uninformed critics and provide greater acceptance. Community relations would be improved by using local people in the planning stages and in project activities. Local people should be contacted at an early date in the area where a project is planned so they can be aware of local capabilities.

For future events, a specific effort to gain a greater understanding of the tasks is a basic "must" for the industrial participants. It appears that some activities can be combined or eliminated. Some tasks require specialized talents; however, others are not nearly so restrictive and can be utilized to provide opportunities to use local personnel. For instance, evacuation activities and portions of the initial safety study could have used trustworthy individuals hired locally.

An observer program may be beneficial in providing publicity for an event but care should be taken to allow more time for site visits. If weather is a detonation factor, as the case of Rulison, then the observer program should be deleted.

APPENDIX A

PROJECT RULISON PERSONNEL ASSIGNMENTS

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APPENDIX A  
PROJECT RULISON PERSONNEL ASSIGNMENTS

FIELD ORGANIZATION

Project Director  
Assistant Project Director  
Site Manager  
DONO  
Deputy DONO  
Alternate Deputy DONO  
Scientific Advisor  
OD  
Chief, Security  
NV Engineering and Logistics  
Site Representative  
PNE/DAT Project Officer  
Chief Operations Coordinator  
NV Radiological Operations  
Representatives

Gerry R. Luetkehans, CER  
Miles Reynolds, Jr., Austral  
Owen Coats, CER  
Robert H. Thalgott, NV  
William W. Allaire, NV  
Rollin H. Shaw, NV  
R. Lee Aamodt, LASL  
Robert H. Campbell, LASL  
Nels W. Johnson, NV  
C. P. Bromley, NV

R. M. Richardson, PNE/DAT  
P. J. Mudra, NV  
D. W. Hendricks, NV  
C. M. Campbell, NV  
L. J. O'Neill, NV  
B. W. Church, NV

RULISON TECHNICAL COMMITTEE

Chairman  
Member  
Member  
Alternate  
Member  
Member  
Member

Bruce G. Bray, CER  
Miles Reynolds, Jr., Austral  
Charles H. Atkinson  
Don C. Ward, USBM  
R. Lee Aamodt, AEC/LASL  
Carroll F. Knutson, CER  
Robert S. Brundage, CER

JOINT OFFICE OF INFORMATION

Director  
Associate Director  
Member  
Member  
Alternate  
Member  
Member

Henry G. Vermillion, NV  
H. H. Aronson, CER  
Miles Reynolds, Jr., Austral  
William Richmond, LASL  
William Regan, LASL  
Charles Lanman, NV  
David F. Miller, NV

RULISON ADVISORY GROUP

Chairman  
Member  
Member  
Member  
Alternate  
Alternate  
Technical Advisor  
Executive Secretary

William E. Ogle, LASL  
Harry L. Reynolds, LLL  
Robert H. Thalgott, NV  
J. Wade Watkins, USBM  
Frank W. Stead, USGS  
Robert T. Johansen, USBM  
Milo D. Nordyke, LLL  
Ben Bowyer, NV

NV PROGRAM DIRECTORS

Construction and Logistics

Richard O. Moss, Director  
Logistics and Construction Division

Effects Evaluation

Elwood M. Douthett, Director  
Effects Evaluation Division

Security

William R. Adair, Director  
Security Division

Public Affairs

Henry G. Vermillion, Director  
Office of Public Affairs

Operations

Rollin H. Shaw, Director  
Operations Division

Radiological Safety

Donald W. Hendricks, Chief  
Radiological Safety Branch

RULISON EVENT OFFICER

Paul J. Mudra  
Office of Test Manager

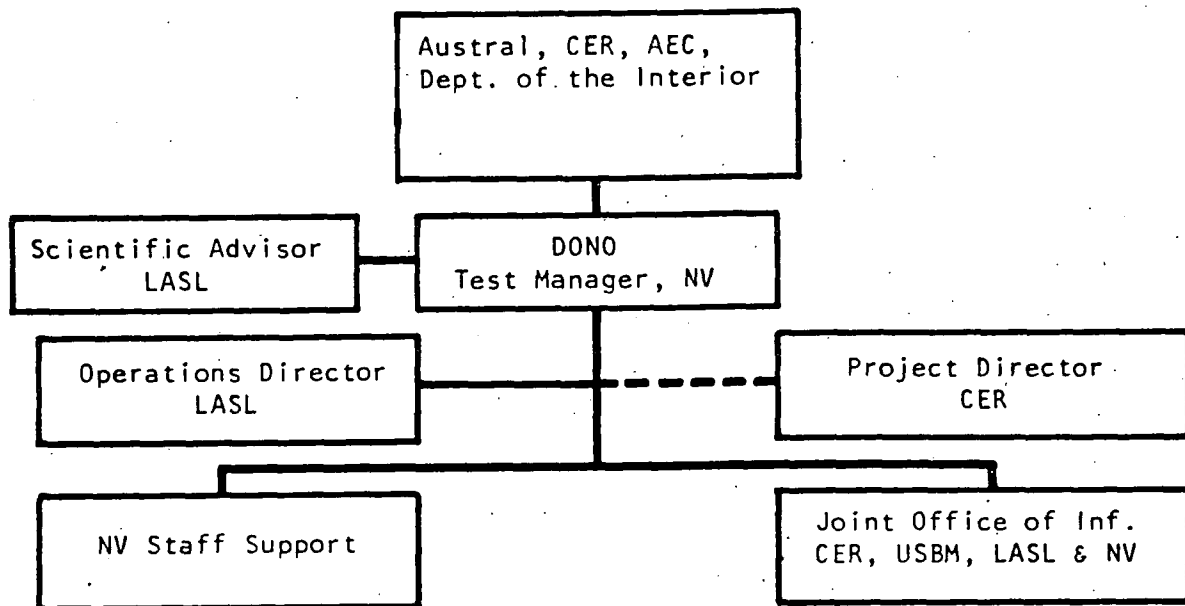
APPENDIX B

PROJECT RULISON ORGANIZATION

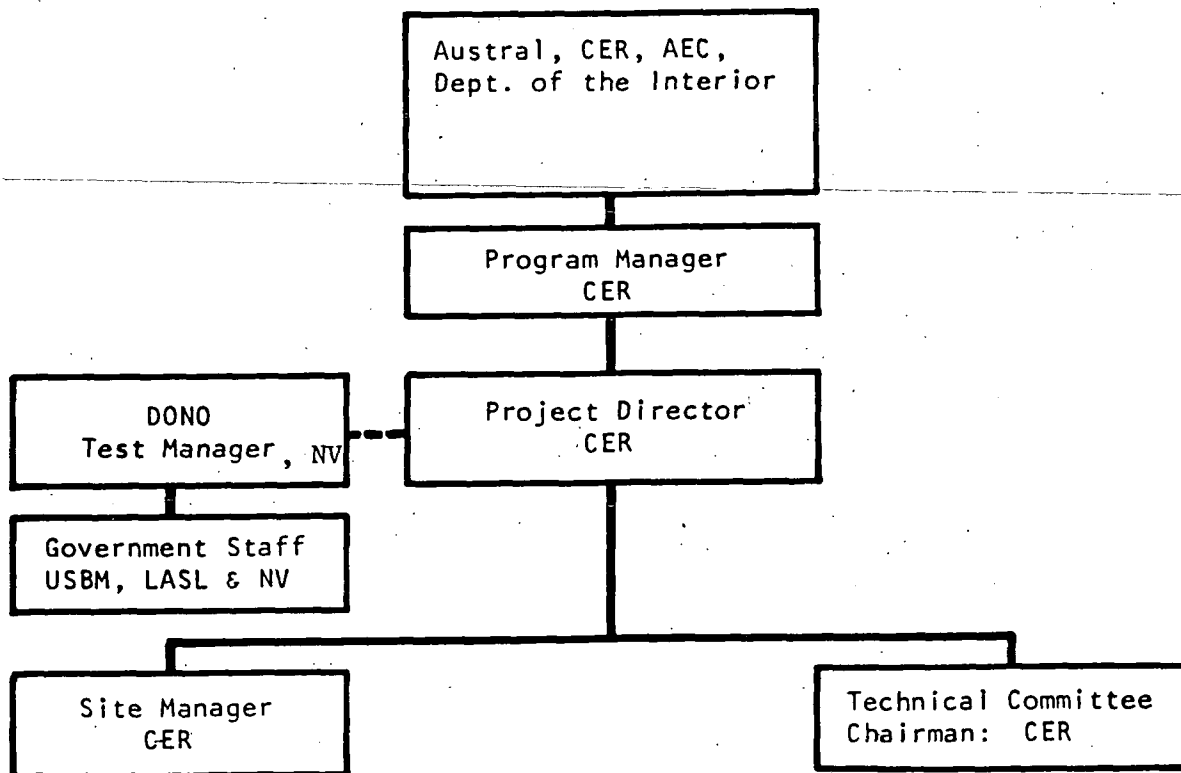
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## NUCLEAR OPERATIONS PHASE



## PROJECT PREPARATION AND EVALUATION PHASE



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APPENDIX C

ORGANIZATIONS PARTICIPATING IN  
PROJECT RULISON

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APPENDIX C  
ORGANIZATIONS PARTICIPATING IN PROJECT RULISON

MAJOR PARTICIPANTS

USAEC  
Department of the Interior  
Austral  
CER  
LASL

FEDERAL ORGANIZATIONS

NV/AEC  
Grand Junction Office/AEC  
DPNE/AEC  
USBM  
USGS  
U.S. Forest Service  
Federal Aviation Administration  
U.S. Air Force  
Federal Bureau of Investigation  
U.S. Attorney--Denver  
113th Military Intelligence Group, Region IV, U.S. Army  
U.S. Marshall--Denver  
U.S. Arms Control and Disarmament Agency  
U.S. Bureau of Reclamation  
U.S. Corps of Engineers  
Advanced Research Projects Agency (ARPA), Department of Defense

STATE OF COLORADO ORGANIZATIONS

Governor Love's Office  
Bureau of Mines  
Dept. of Public Health  
State Highway Patrol  
Game, Fish, and Parks Dept.  
Water and Air Pollution Commission  
Div. of Dams and Reservoirs  
Director of Natural Resources  
Dept. of Highways  
National Guard

COUNTY ORGANIZATIONS

Mesa County Commissioners  
Mesa County Highway Dept.  
Mesa County Sheriff  
Garfield County Sheriff  
Garfield County Commissioners

### PRIVATE ORGANIZATIONS

Denver and Rio Grande Western Railroad  
Nuclear Insurance Pool (NELIA)

### NV CONTRACTORS

BMI	Bioenvironmental
F&S	A/C Subsurface
H&N	A/E Surface
REECO	Support
EG&G	Operations Support
GAB	Claims
EPA/NERC	Offsite Rad-Safe
EIC	Onsite Rad-Safe
NOAA/ARL	Weather
NOAA/ESL	Seismic Instrumentation
USGS	Geology-Hydrology
USBM	Mine & Well Survey
JAB	Structural Response
ERC	Ground Motion Predictions
Isotopes	Groundwater Contamination
WES	Soils Materials
WSI	Security
Texas Instruments (ARPA Contractor)	

### ORGANIZATIONS PROVIDING REVIEW MEMBERS

LLL  
SL  
Test Command, DNA  
SAN/AEC  
ALO/AEC

### AUSTRAL/CER SUBCONTRACTORS

William F. Harwood, Inc.	General Contractor
Wesco Electric Company	Electrical
Intermountain Printing & Stationery Co.	Office Furniture, Equipment, and Supplies
Elder Equipment Leasing Corp.	Office Trailers
Trailer Home Rental & Sales, Inc.	Miscellaneous Office Trailers
Suburban Gas Company	Propane
Holy Cross Electric Association	Commerical Electricity at Site
Public Service Company of Colorado	Commercial Electricity Elsewhere
Red Crawford, Inc.	Communications Service
Reed Miller, Inc. (Hertz)	Vehicle Rental
Mountain States Tel. & Tel. Co.	Telephone Service
Rippy Construction Company	Road Maintenance and Similar Activities
FMC Corporation	Well Head Equipment and Testing
Dresser-Atlas-	Winch Operator and Wireline Service
Scarrow Engineering	Surveying
Claggett Memorial Hospital	Industrial Safety Support

Roger Johnson and Charles  
Pfalcgraff  
Western Union Telegraphy Company

AVIS  
Continental Trailways  
Wambolt Guard Service  
Jack Spann  
Mesa County Road Dept. &  
Richard Lloyd

Base Town Office and Warehouse Space

Facsimile Hookup for ARL in Grand  
Junction

Vehicle Rental

Bus Rental

Watchmen Service

Office Space, Grand Junction

Land Lease for Communication  
Equipment

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APPENDIX D  
PUBLIC ANNOUNCEMENTS

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U.S. ATOMIC ENERGY COMMISSION  
GRAND JUNCTION OFFICE  
GRAND JUNCTION, COLORADO

No. 489  
Public Information Office  
Tel. 242-8621, Ext. 201

For Release  
12 Noon, MDT  
Monday, June 10, 1968

PROJECT RULISON MEETING SCHEDULED IN GRAND JUNCTION, JUNE 11-13

Participants in a proposed experiment to increase natural gas production by rock fracturing with nuclear explosives will meet in Grand Junction, Colorado, June 11-13 to discuss the project and visit the proposed site.

The experiment, called Project Rulison, has been formally proposed to the AEC by Austral Oil Company of Houston, Texas, with assistance from its nuclear advisor, CER Geonuclear of Las Vegas, Nevada. The proposal is under active consideration by the AEC along with several other possible industrial-use experiments in the Commission Plowshare program to develop peaceful uses for nuclear explosives.

Representatives from Austral, CER, the AEC's Nevada Operations Office, the Los Alamos Scientific Laboratory, and the Department of Interior's Bureau of Mines and Geological Survey will attend the meeting. Should Project Rulison be authorized and funded, the AEC's Nevada Operations Office at Las Vegas would be responsible for nuclear operations and public safety. Austral and CER would be responsible for construction and test support. The Los Alamos Scientific Laboratory at Los Alamos, New Mexico, which is operated for the AEC by the University of California, would be responsible for the technical aspects of the nuclear portion of the experiment.

The Department of the Interior's Bureau of Mines, jointly with CER and Austral, would be responsible for development of the reservoir evaluation portion of the technical program. The Bureau, as part of the Department of the Interior, also would serve as liaison with other Interior agencies on Rulison matters such as the acquisition of hydrologic and geologic data by the U.S. Geological Survey and land usage permits, if required, from the Bureau of Land Management.

Austral recently completed a test well for the proposed project, and is conducting a series of reservoir tests in the well. The group at the meeting will review data from these tests, which apply to hydrology, gas production, and gas quantity, and will determine requirements for additional tests.

The tests will be used to determine the technical suitability of the site, including safety. Should the experiment be authorized, comparisons would be made of gas production from the reservoir before and after the underground nuclear explosion. The nuclear explosion would be expected to increase natural gas production significantly by fracturing the rock formation in which the gas is trapped.

The group will visit the proposed test site in Garfield County some 45 miles northeast of Grand Junction on June 12. After the visit to the proposed

Rulison site, the group will discuss proposed locations of test facilities, preliminary safety considerations, construction, and logistical matters.

Rulison would require a higher yield nuclear explosive than Project Gasbuggy, the first natural gas stimulation experiment which took place near Farmington, New Mexico, in December 1967. A higher yield would be needed because the Rulison gas-bearing formation is considerably thicker than the Gasbuggy formation and more extensive rock fracturing would be required.

The Pictured Cliffs formation at the Gasbuggy site was about 300 feet thick, lying about 3,900 feet underground. Rulison's gas-bearing Mesa-verde formation ranges in thickness from 2,500 to 4,000 feet and is some 7,500 to 8,500 feet underground. Rulison may call for an explosive in the 50-kiloton range--the equivalent of 50,000 tons of TNT--compared to 26 kilotons for Project Gasbuggy.

Because of the greater quantity of gas in place at the proposed site, Rulison could be a test in a potentially commercial field, whereas Gasbuggy was designed to be wholly experimental in character. Gas production and gas quality tests are continuing at the Gasbuggy site and the final results and conclusions are expected about a year from now. Rulison would be a similar experiment but in a different geologic medium, a different gas field, and at much greater depth. Rulison would add to knowledge needed if nuclear explosive stimulation of natural gas production is to be applied to other gas fields at other locations. It is not anticipated that the nuclear explosion part of the Rulison experiment would take place until after more data from the Gasbuggy experiment are available.

UNITED STATES  
ATOMIC ENERGY COMMISSION  
Nevada Operations Office  
Post Office Box 14100  
Las Vegas, NV 89114

February 6, 1969

Office of Public Affairs  
2753 South Highland  
Telephone: 734-3851

FOR IMMEDIATE RELEASE

The U.S. Atomic Energy Commission and the Department of the Interior have begun negotiation of a contract with Austral Oil Company, Inc., to study the feasibility of using a nuclear explosion deep underground in Colorado to increase production rates and recovery of natural gas.

Negotiations began February 4 in Las Vegas between the Government, represented by the AEC's Nevada Operations Office and the Bureau of Mines on behalf of the U.S. Department of the Interior, and the industrial sponsor of the proposed project, Austral Oil Company, Incorporated, of Houston, Texas, who, with the nuclear engineering consulting firm of CER Geonuclear Corporation of Las Vegas, Nevada, formally proposed the project to the AEC in December 1966. Negotiations with Austral as principal and CER as program manager were authorized after the extensive review of the proposed project, including safety criteria by the AEC.

The experiment, called Project Rulison, would be the second natural gas stimulation experiment in the AEC's Plowshare Program to develop peaceful uses for nuclear explosives, and the first of a series needed to gather data on commercial applications. The first experiment was Project Gasbuggy, a joint experiment of the AEC, El Paso Natural Gas Company, and the Department of the Interior. Data from the 26-kiloton Gasbuggy detonation 4,200 feet underground in northwestern New Mexico in December 1967 are still being collected and analyzed.

Rulison would be a 40-kiloton nuclear detonation 8,400 feet underground about 15 miles from Rifle, Colorado. The experiment is planned for late spring 1969, depending upon the outcome of contract negotiations and subject to approvals for use of the device. Rulison would provide additional and more sophisticated information required to further evaluate the economic feasibility of nuclear stimulation. Such information would include the effects of nuclear detonations on a gas formation that is geologically different from Gasbuggy, the effects on explosive performance of increased temperatures and pressures at greater depths, and the effects of higher yield detonations in stimulating the production of natural gas.

The gas-bearing Mesaverde formation under Austral's properties in Garfield County, Colorado, contains an estimated 8 trillion standard cubic feet of gas in place, but the reservoir is not commercially productive using conventional well completion techniques. Rulison is the first nuclear stimulation project proposed for a reservoir that could support commercial gas production if the stimulation technique is proved feasible.

Successful nuclear stimulation at the Rulison field would add to the recoverable gas reserves of the nation and, since more than 50 percent of the acreage is on Federal Government leases, the Government could derive significant royalties from gas production from this field.

In April 1968, the AEC assigned the Los Alamos Scientific Laboratory to work with Austral, CER, and Bureau of Mines personnel to incorporate the laboratory's concept for nuclear explosive emplacement and detonation in project planning. The laboratory at Los Alamos, New Mexico, is operated for the AEC by the University of California.

In May 1968, Austral completed the Rulison project exploratory well at the proposed Project Rulison site under an agreement with the U.S. Geological Survey. Review of the hydrologic and geologic data from this well, plus meteorological, ecological, and seismic data by the AEC, is being completed to determine if the proposed detonation could be conducted safely.

NV-69-25

UNITED STATES  
ATOMIC ENERGY COMMISSION  
Nevada Operations Office  
Post Office Box 14100  
Las Vegas, NV 89114

February 28, 1969

Office of Public Affairs  
2753 South Highland  
Telephone: 734-3851

FOR IMMEDIATE RELEASE

Negotiations have been concluded for a proposed contract between the Federal Government and industry to detonate a nuclear explosive deep underground in Colorado in an experiment to stimulate natural gas recovery. The terms of the proposed contract now are subject to review and approval by all parties to it.

The Government was represented in the negotiations by the Atomic Energy Commission and the Department of the Interior. The experiment's industrial sponsor is Austral Oil Company, Incorporated, of Houston, Texas. A nuclear engineering firm, CER Geonuclear Corporation of Las Vegas, would act as program manager for the experiment, called Project Rulison.

Project Rulison would involve the detonation of a 40-kiloton (the equivalent of 40,000 tons of TNT) nuclear explosive in a natural gas-bearing formation some 8,400 feet underground in the Rulison gas field about 15 miles southwest of Rifle, Colorado. The explosion is expected to fracture large volumes of rock in which the gas is tightly trapped, thus stimulating production and ultimate recovery of the gas.

Rulison is the first nuclear stimulation project proposed for a gas reservoir that could support commercial production. Rulison would provide some of the additional technical information required to evaluate the economic feasibility of nuclear stimulation.

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Under the terms of the proposed contract, Austral would provide all work and services for the project except for the nuclear explosive and certain related services such as explosive timing and firing and nuclear operational safety procedures. These would be the responsibility of the AEC. It is expected the detonation could take place in late spring 1969.

UNITED STATES  
ATOMIC ENERGY COMMISSION  
Nevada Operations Office  
Post Office Box 14100  
Las Vegas, NV 89114

March 18, 1969

Office of Public Affairs  
2753 South Highland  
Telephone: 734-3851

(NOTE: The following was released by USGS in Denver and by the AEC in Grand Junction. It is being distributed by NVOO for information only.)

A sample of well owners in the valley of the Colorado River between DeBeque and Rifle and Plateau and Buzzard Creeks will be visited by a U.S. Geological Survey technical team during the period March 17-28, 1969. The team will establish the condition of the water wells that conceivably could be affected by the detonation of the nuclear device for Project Rulison in Garfield County about 6 miles southeast of Grand Valley, Colorado.

Project Rulison, which is planned for late May 1969, is an experiment designed to stimulate gas production in the Rulison field by fracturing the rock in which the gas is tightly trapped. The detonation of the 40-kiloton nuclear device will occur about 8,500 feet underground.

The detonation is expected to cause detectable ground motion in parts of the inhabited area of the valley. However, experience gained from 270 detonations at the Nevada Test Site and from 5 off-site detonations in Mississippi, Nevada, New Mexico, and Alaska provided the initial safety criteria for selecting this site. This experience shows that if damage to pumps and wells occurs, it has been minor.

The Atomic Energy Commission is authorized to make prompt payment for any damage shown to result from the detonation.

The U.S. Geological Survey was selected to make the well appraisals because of its technical competence in evaluation of well conditions. The team, headed by R. T. Hurr, U.S. Geological Survey hydrologist, consists of Frank Welder, Robert Emerson, and Woodrow Wilson, all from Denver.

Mr. Hurr solicits the cooperation of well owners.



UNITED STATES  
ATOMIC ENERGY COMMISSION  
Nevada Operations Office  
Post Office Box 14100  
Las Vegas, NV 89114

March 26, 1969

Office of Public Affairs  
2753 South Highland  
Telephone: 734-3851

FOR IMMEDIATE RELEASE

(The following is being issued simultaneously in Washington, D.C., Las Vegas, Nevada, and Grand Junction, Colorado.)

An agreement providing for the nation's second experiment to investigate the use of a nuclear explosion to increase the recovery of natural gas was signed today by the U.S. Government, the industrial sponsor, Austral Oil Company, Incorporated, of Houston, Texas, and CER Geonuclear Corporation of Las Vegas, Nevada, acting as Program Manager.

The agreement for the conduct of this cooperative Government-industry research and development project was signed in Washington on behalf of the Government by Undersecretary of the Interior Russell E. Train and Chairman Glenn T. Seaborg of the Atomic Energy Commission. It was signed for Austral Oil Company by C. Wardell Leisk, Chairman, and for CER Geonuclear by Herbert E. Grier, President.

The experiment, Project Rulison, will be conducted at a site about 12 air miles southwest of Rifle, Colorado. The nuclear explosion will take place deep in a low-permeability--or "tight"--gas-bearing formation (the Mesa-verde formation). Natural gas cannot be produced economically from this formation using conventional stimulation and production techniques. The nuclear explosion tentatively has been scheduled for the latter part of May of this year.

The 40-kiloton (equivalent to 40,000 tons of TNT) nuclear explosive will be emplaced at a depth of about 8,400 feet below the surface. The explosion is expected to create an underground chimney of broken rock about 370 feet high and 160 feet in diameter. The chimney would act as a chamber where the gas would collect, then be drawn off through a well to be drilled back into the chimney. The energy released by the explosion is expected to crush and fracture the rock out to about 290 feet around the chimney.

The Rulison experimental program is divided into three phases, the first of which has been essentially completed by Austral Oil Company at its own expense. It included the feasibility study, all detailed project planning and definition plus drilling a preshot exploratory hole and performing preshot gas production tests, and the drilling of an emplacement hole for the nuclear explosive. Preliminary geological, hydrological, and other studies were conducted to confirm the suitability of the site from a safety and technical standpoint.

Phase Two includes additional detailed safety studies in hydrology, ecology, and structural response, which are still in progress, along with the construction of surface facilities, emplacement and detonation of the nuclear explosive, and measurements of the detonation-time effects.

Phase Three will be initiated about six months after the explosion to permit short-lived radioactivity in the chimney to decay. It will include postshot drilling and investigations of the effects of the nuclear detonation on gas quality and production rates. Introduction of natural gas produced by Rulison into commercial pipelines is not part of the experiment.

Under the agreement, Austral is performing all drilling and other work and services related to the experiment--except for providing the nuclear explosive and related safety and operational functions, which will be performed by the AEC. The nuclear engineering firm of CER Geonuclear is acting as program manager for the project, and also will cooperate with the Department of the Interior's Bureau of Mines in making the measurements and calculations of reservoir performance following nuclear stimulation. It will take more than a year to obtain and analyze all the data.

The Atomic Energy Commission, through its Nevada Operations Office in Las Vegas, is responsible for supervising and operational, safety, and security aspects relating to the nuclear explosion. The AEC's Los Alamos (New Mexico) Scientific Laboratory, operated by the University of California, has responsibility for the design and development of the nuclear explosive program.

The Bureau of Mines is conducting, in cooperation with Austral and CER, the evaluation of reservoir characteristics. The Bureau estimates that if the use of nuclear explosions to increase the recovery of natural gas proved to be technically and economically feasible, the technique could add 317 trillion cubic feet of natural gas to the nation's proved reserves. The nation's present recoverable reserves are estimated to be 293 trillion cubic feet.

The first experiment to study this application of contained underground nuclear explosions, Project Gasbuggy, is a joint project of the Atomic Energy Commission, the Department of the Interior, and El Paso Natural Gas Company. The nuclear explosion portion of the experiment was conducted on December 10, 1967, in northwestern New Mexico. The gas production phase of the Gasbuggy experiment is still in progress.

The Rulison experiment will extend data on nuclear stimulation obtained from Gasbuggy to include information on the effects of a nuclear explosion in a gas reservoir that could support commercial production. It also is expected to provide some of the additional information required to further evaluate the technical and economic feasibility of nuclear stimulation--including the effects of a higher-yield nuclear explosion on a gas-bearing formation located about one and one-half miles below the surface of the ground. Project Gasbuggy involved the detonation of a 26-kiloton nuclear explosive at a depth of 4,240 feet.

NV-69-46

UNITED STATES  
ATOMIC ENERGY COMMISSION  
Nevada Operations Office  
Post Office Box 14100  
Las Vegas, NV 89114

April 4, 1969

Office of Public Affairs  
2753 South Highland  
Telephone: 734-3851

(NOTE: The following was issued in Grand Junction, Colorado, Friday, April 4, and is distributed by NVOO for information.)

The U.S. Atomic Energy Commission, the Department of the Interior's Bureau of Mines, Austral Oil Company, Incorporated, and CER Geonuclear Corporation will conduct public meetings on Project Rulison in five Colorado communities during the week of April 14.

Project Rulison is the second experiment in the AEC's Plowshare Program to investigate the use of a nuclear explosion to increase the recovery of natural gas. It is a cooperative government-industry research and development project calling for detonation of a 40-kiloton nuclear explosive (equivalent to 40,000 tons of TNT) some 8,400 feet underground in the Mesaverde natural gas bearing formation. The detonation, planned for May 22, will take place about 12 air miles southwest of Rifle, Colorado.

Public meetings to explain the project, including nuclear detonation effects and the public safety program, will be held in Grand Junction, Grand Valley, Rifle, Glenwood Springs, and Meeker. Except for a 3:30 p.m. meeting at the Grand Valley High School on April 14, the meetings will be held at 8 p.m. All persons interested in attending the meetings, including residents of other communities, are welcome to attend and ask questions if they wish.

The meeting in Rifle will be at the Esma Lewis Elementary School on Monday, April 14; Glenwood Springs High School on Tuesday, April 15; Meeker High School on Wednesday, April 16; and the Mesa Junior College Auditorium, 1120 North Avenue, in Grand Junction on Thursday, April 17.

Project participants also will conduct a briefing on Rulison for Colorado officials from the Department of Natural Resources, Department of Public Health, State Highway Department, and the State Highway Patrol on Friday, April 18.

Subjects to be discussed at the public meetings and the briefing for State officials include: nuclear test operations and safety, off-site safety precautions, potential of nuclear stimulation of gas reservoirs, purpose and anticipated results of Rulison, and nuclear effects. There will be a question and answer session after the presentations.

UNITED STATES  
ATOMIC ENERGY COMMISSION  
Nevada Operations Office  
Post Office Box 14100  
Las Vegas, NV 89114

April 14, 1969

Office of Public Affairs  
2753 South Highland  
Telephone: 734-3851

FOR IMMEDIATE RELEASE

The Project Rulison underground nuclear detonation near Rifle, Colorado, the second industrial experiment in the nation's Plowshare Program to develop peaceful uses for nuclear explosions, may be delayed to permit completion of the necessary safety studies. Every effort will be made to minimize any delay.

The detonation tentatively had been scheduled for May 22. The 40-kiloton explosion at a depth of 8,400 feet is designed to investigate enhancing natural gas production in a relatively impermeable formation.

After the contract between the Government and the industrial sponsor had been signed, detailed safety reviews and analyses, based on previously collected data, were begun. The first report based on these reviews was available only last week. On the basis of the report, the Panel of Safety Consultants to the Nevada Operations Office of the U.S. Atomic Energy Commission noted that some safety studies still are to be completed, including further study of the Harvey Gap Dam about 20 miles from the detonation point.

Public meetings scheduled with residents of communities closest to Project Rulison will be conducted beginning April 14. Sessions are to be held in Grand Valley and Rifle on April 14, in Glenwood Springs on April 15, in Meeker on April 16, and in Grand Junction on April 17. Officials of the State of Colorado are to be briefed in Denver on April 18.

Project Rulison is a joint project of the AEC and the Department of the Interior's Bureau of Mines, the industrial sponsor, Austral Oil Company, Inc., of Houston, Texas, and CER Geonuclear Corporation of Las Vegas, Nevada, acting as Program Manager.

NV-69-66

UNITED STATES  
ATOMIC ENERGY COMMISSION  
Nevada Operations Office  
Post Office Box 14100  
Las Vegas, NV 89114

May 7, 1969

Office of Public Affairs  
2753 South Highland Drive  
Telephone: 734-3851

FOR IMMEDIATE RELEASE

The Project Rulison 40-kiloton underground nuclear detonation which tentatively had been scheduled for May 22 at a site near Rifle, Colorado, has been rescheduled for next September. Rulison will be the second in a planned series of joint Government-industry experiments to investigate the use of a contained nuclear explosion to enhance the recovery of natural gas from low-permeability gas formations.

The project is jointly sponsored by the U.S. Atomic Energy Commission, the Bureau of Mines of the U.S. Department of the Interior, the industrial sponsor, Austral Oil Company, Inc., of Houston, and CER Geonuclear Corporation of Las Vegas, acting as Program Manager.

The decision to reschedule the detonation was made by the project participants after it was determined that the necessary preparations to conduct the nuclear explosion could not be completed in time to meet the May 22 date.

The necessary preparations to conduct the nuclear explosion portion of Project Rulison in September will continue through the summer, and a new ready date will be announced well in advance.

UNITED STATES  
ATOMIC ENERGY COMMISSION  
Nevada Operations Office  
Post Office Box 14100  
Las Vegas, NV 89114

August 11, 1969

Office of Public Affairs  
2753 South Highland  
Telephone: 734-3851

(NOTE: The following was released to news media in Colorado at 9 a.m.,  
MDT, Friday, August 8, 1969.)

The Austral Oil Company, Incorporated, CER Geonuclear Corporation, the  
U.S. Atomic Energy Commission, and the Department of the Interior's  
Bureau of Mines will conduct a public meeting on Project Rulison in  
Collbran on August 21.

Project Rulison is the second experiment in the AEC's Plowshare Program  
to investigate the use of a nuclear explosion to increase the recovery of  
natural gas. It is a cooperative Government-industry research and develop-  
ment project calling for detonation of a 40-kiloton nuclear explosion  
(equivalent to 40,000 tons of TNT) some 8,400 feet underground in the  
Mesaverde natural gas-bearing formation. The detonation, planned for  
September 4, will take place about 12 air miles north of Collbran and  
12 air miles southwest of Rifle, Colorado.

A public meeting to explain this project, including nuclear detonation  
effects and the public safety program, will be held in Collbran on  
August 21 at 8 p.m. at the Plateau Valley School. All persons interested  
in attending the meeting, including residents of other communities, are  
welcome to attend and ask questions if they wish.

Subjects to be discussed include: nuclear operations and safety, off-site  
safety precautions, potential of nuclear stimulation of gas reservoirs,  
purpose and anticipated results of Rulison, and nuclear effects. There  
will be a question and answer session after the presentations.

U.S. ATOMIC ENERGY COMMISSION  
GRAND JUNCTION OFFICE  
GRAND JUNCTION, COLORADO

No. 530  
Public Information Office  
Tel. 242-8621, Ext. 201

For Release at  
10:00 A.M., MDT  
Monday, August 11, 1969

NOTE TO EDITORS AND CORRESPONDENTS

(The following is being issued simultaneously at AEC Headquarters in Washington, D.C., and at several other field offices.)

The Atomic Energy Commission, Austral Oil Company, Incorporated, U.S. Department of the Interior, and CER Geonuclear Corporation invite news media representatives to attend a predetonation discussion and to be present for an underground nuclear detonation planned for September 4, 1969, near Grand Junction, Colorado.

Project Rulison is one in a series of experiments designed to determine the technical and economic feasibility of enhancing the recovery of natural gas through the use of nuclear explosions. It calls for a detonation of a 40-kiloton nuclear explosive 8,430 feet underground in the gas-bearing Mesaverde formation of the Rulison field, in Garfield County, Colorado. The nuclear explosion is expected to fracture a large volume of rock to allow the gas in the formation to flow to a postshot wellbore. The production rate and total production from the nuclear-stimulated well are expected to be several times greater than from a conventional well.

Project Rulison is the second joint government-industry experiment in the AEC's Plowshare Program to develop peaceful uses of nuclear explosives. The experiment is expected to cost about \$6.5 million.

Delays or Postponement

It is anticipated that the attached schedule will be followed. However, weather or technical difficulties may delay the experiment for several hours or postpone it for days. Information about postponements may be obtained by calling the Grand Junction Chamber of Commerce--303-242-3214; or the Project Rulison Joint Office of Information in Grand Valley--303-285-7566.

Registration

Registration for news media representatives and official visitors will be held in the Executive Room of the Ramada Inn, 718 Horizon Drive, Grand Junction, Colorado, September 2 and 3, from 10 a.m. to 6 p.m. Registration is essential to arrange transportation to the visitor area and obtain other pertinent data. You will be given a badge which will identify you as an official visitor to Project Rulison.

### Predetonation Briefing

The briefing by personnel representing the organizations participating in Project Rulison will be held at Mesa Junior College, 1120 North Avenue, Grand Junction, Colorado, at 7 p.m., September 3. The briefing is open to the public.

### Transportation

United Air Lines and Frontier Air Lines serve Grand Junction. Buses will pick up news media representatives and official visitors at designated points in Grand Junction on the morning of the detonation. The exact times and places for pickup will be available at registration time. No private automobiles will be allowed at the visitor area.

### Visitor Housing

The Grand Junction Chamber of Commerce will assist in obtaining accommodations for Project Rulison official visitors. Visitors will be housed at their own expense with reservations on a "first come" basis.

Reservations for rooms should be made through

Grand Junction Chamber of Commerce  
127 North Fourth Street  
Grand Junction, CO 81501

Telephone: 303-242-3214

### The Rulison Site

The Rulison site is about 40 miles northeast of Grand Junction on the northern slope of Battlement Mesa. The visitor area is north of the Colorado River about six miles from the Rulison site. From the visitor area, the site directly above the point of detonation (Surface Ground Zero), is visible and will be marked at detonation time by a large, colored weather balloon.

The only apparent effect of the explosion at the visitor area is expected to be a minor ground movement as the seismic wave passes through the area.

### Visits to the Detonation Site

News media representatives, including photographers, who wish to visit the Rulison detonation site and its facilities before detonation day may do so by writing or telephoning: David F. Miller, Project Rulison Joint Office of Information, Grand Valley, Colorado 81635, Telephone: 303-285-7566. The Joint Office of Information will be open in Grand Valley on August 11, 1969. Visits to the site may be made after the Joint Office of Information opens except for periods when operations or safety require exclusion. After the detonation, it will not be possible to visit the detonation site for at least several hours.



### Communications

The nearest communities with telephone service are Grand Valley, six miles northwest of the site, and Rifle, 12 miles northeast of the site. Both communities are located on Colorado State Route 6.

### Climate

September in Colorado is generally warm with temperatures from 70 degrees Fahrenheit to 90 degrees Fahrenheit during the day and 60 degrees Fahrenheit to 70 degrees Fahrenheit at night. Rain showers are possible so visitors should be prepared.

### For News Media Representatives

News media representatives planning to be present for the Rulison event should write to: Project Rulison, c/o CER Geonuclear Corporation, Post Office Box 15090, Las Vegas, Nevada 89114.

Foreign news media representatives planning to attend should submit a letter to John A. Harris, Director, Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545, Attention: Frank Ingram.

SCHEDULE OF EVENTS  
PROJECT RULISON

D-DAY MINUS TWO

10:00 a.m. to 6:00 p.m.

Registration at Ramada Inn,  
718 Horizon Drive, Grand Junction,  
Colorado.  
Registration for all Official  
Visitors.

D-DAY MINUS ONE

10:00 a.m. to 6:00 p.m..

Registration at Ramada Inn.

7:00 p.m.

Predetonation Discussion--  
Mesa Junior College  
1120 North Avenue  
Grand Junction, Colorado  
General Discussion of Project  
Rulison. Public is invited.

D-DAY

(Time of Detonation to be  
Determined.)

DETONATION MINUS 3 1/2 to  
3 HOURS

Bus Pickup for Transportation  
to Observer Area. Buses will  
pick up official visitors at  
designated points.

DETONATION MINUS 1 1/2 to  
1 HOUR

Buses Arrive at Observer Area.

DETONATION MINUS 30 MINUTES

Countdown for Nuclear Explosion.  
Predetonation Briefing at Observer  
Area. Important aspects of the  
countdown will be explained to the  
official visitors.

DETONATION

Project Rulison.  
Lunch will be served at the Visitor  
Area. A preliminary postdetonation  
briefing is planned. Buses will re-  
turn to Grand Junction about two hours  
after detonation.

JOI-1-69

PROJECT RULISON  
Joint Office of Information  
Grand Valley, CO 81635

August 12, 1969

Telephone: 303-285-7566

FOR IMMEDIATE RELEASE

Members of the Project Rulison organization will be in Grand Valley at the Grand Valley School at 7:30 p.m. on Tuesday, August 19, to discuss steps to be taken to assure public safety at the time of the Rulison explosion, now planned for September 4. Plans for roadblocks in the area, evacuation procedures, plans for caring for ill or infirm residents in the area, and other safety precautions will be discussed. The status of the project also will be discussed. The meeting is open to the public and questions about any aspect of the project are welcome.

PROJECT RULISON  
Joint Office of Information  
Grand Valley, CO 81635

Telephone: 303-285-7566

FOR IMMEDIATE RELEASE

Hunters and fishermen were cautioned today not to venture on Battlement Mesa, 40 miles northeast of Grand Junction, two days before and the day of Project Rulison's underground nuclear detonation, now scheduled for about 3 p.m. Thursday.

Glenn Rogers, regional Manager of the Colorado Game, Fish, and Parks Division, said he is particularly concerned about bow hunters, since the bow season is now open.

"We are suggesting that hunters and fishermen stay away from Battlement Mesa next Tuesday, Wednesday, and Thursday," he said. "If the detonation is delayed due to weather or technical difficulties, then the restricted period would be changed accordingly."

If hunters have questions about the days they should avoid the Battlement Mesa, they should contact the Game, Fish, and Parks offices in Grand Junction, Rifle, or Collbran, Rogers said.

Project Rulison's 40-kiloton underground detonation is a joint government-industry experiment to gather data on nuclear stimulation of low-permeability gas formations.

PROJECT RULISON  
Joint Office of Information  
Grand Valley, CO 81635

Telephone: 303-285-7566

FOR IMMEDIATE RELEASE

Persons within 50 miles of Project Rulison's 40-kiloton underground explosion were alerted today to stay off precarious places during the detonation, scheduled for 3 p.m. Thursday.

Local radio stations, KWSR radio, 810, in Rifle, and KREX radio, 920, in Grand Junction, will carry the detonation countdown and will announce any delays or postponements of the detonation time.

The test site is high on Battlement Mesa, some 6.5 miles southeast of the community of Grand Valley on U.S. Highway 6-24 (Interstate 70) and 40 miles northeast of Grand Junction.

Towns and communities that are near the outer boundary of the 50-mile circle include Grand Junction on the west, Meeker to the north, Dotsero on the east, and a point some 10 miles south of Delta to the south.

These towns indicate the outer boundary of the circle; any point closer than these to the site near Grand Valley would be in the affected area.

Robert H. Thalgott, Rulison nuclear test manager, said that some slight ground motion from the explosion probably will be felt at this distance. If someone were on a ladder, scaffolding, a roof, or a high wall, he might become startled and lose his balance, Thalgott said.

No damage to property is expected beyond a few miles from the detonation site. However, many people will be able to feel ground motion at intensities well below the levels that may cause damage.

Thalgott suggested that workmen in industrial plants within the 50-mile radius also should refrain from being in high places at shot time.

Bric-a-brac and other highly breakable items in private dwellings should be removed from shelves and walls and placed where they cannot fall, Thalgott suggested.

Project Rulison is a joint government-industry experiment to gather data on the feasibility of recovering gas in tight formations by nuclear stimulation. Austral Oil Company, Incorporated, of Houston is the industrial sponsor of the project.

PROJECT RULISON  
Joint Office of Information  
Grand Valley, CO 81635

Telephone: 303-285-7566

FOR IMMEDIATE RELEASE

Claims for any damages which may result from the 40-kiloton underground nuclear explosion near Rifle, Colorado, now scheduled for Thursday (September 4) will be settled quickly and with a minimum of delay.

Only about 40 families live within five miles of the detonation site, and most of these live more than three miles from the site.

Most of the damage is expected to be limited to broken windows, bric-a-brac, cracked plaster, and damaged chimneys.

Regardless of the type of damage and its extent, claims will be settled simply and promptly as possible.

The General Adjustment Bureau, Inc., a national organization to settle insurance-type claims, will open an office in Grand Valley on September 4.

The office's mailing address will be: Project Rulison Claims Office, 143 West First Street, Post Office Box 216, Grand Valley, Colorado 81635. The telephone number is 285-7541.

Damage claims should be filed with this office, either by letter, telephone, or in person.

After a complaint has been filed with the office, an adjuster from the General Adjustment Bureau will investigate the complaint and if it is found valid, payment will be made by the Bureau within two to four days, in most cases.

Damage claims of an emergency nature--such as broken windows, waterlines, and electrical wiring--will receive special attention, and repairs or payment will be made even more promptly.

Austral Oil Company, Incorporated, of Houston, the industrial sponsor of Project Rulison, is responsible for the first \$10,000 in claims.

After that amount is spent, additional valid claims will be settled administratively by the AEC up to a limit of \$5,000 each. Claims in excess of \$5,000 will be referred through appropriate channels to the U.S. Congress for legislative action to authorize payment.

The Price-Anderson Act provides for the possible payment of up to \$500 million in total damages.

PROJECT RULISON  
Joint Office of Information  
Grand Valley, CO 81635

Telephone: 303-285-7566

FOR IMMEDIATE RELEASE

A comprehensive briefing on Project Rulison by government scientists, state officials, and representatives of Austral Oil Company, Incorporated, is scheduled for 9 a.m. Thursday (September 4) in Grand Junction, Colorado.

Austral is the industrial sponsor of the 40-kiloton underground detonation which seeks to determine the feasibility of stimulating production of natural gas from low-permeability formations.

The site of the 8,442-foot-deep explosion is high on Battlement Mesa 40 miles northeast of Grand Junction and about 6 miles from the small community of Grand Valley in western Colorado. H-hour is set for 3 p.m. Thursday.

Speakers at the morning briefing include Dr. Lee Aamodt of the Los Alamos Scientific Laboratory; Dr. Frank Stead, U.S. Geological Survey; Dr. John K. Emerson, Colorado State Department of Health; Robert H. Thalgott, Atomic Energy Commission Site Test Manager; C. W. Leisk, chairman and president of Austral, and Miles Reynolds, Jr., project engineer for Austral.

The scientists will discuss nuclear phenomenology, hydrology and geology, and seismic and radiological safety.

Reynolds will outline Austral's objectives in Project Rulison.

Between 500 and 600 guests, who have accepted invitations to be official observers, will attend the briefing and then go by bus to the observers' site, approximately 6.5 miles from surface ground zero of the experimental gas well.

At the observers' site, they will have lunch, hear additional speakers, and listen to a countdown for the detonation of the nuclear device.

The observers will not be able to see the well site, but they will see a huge marker balloon floating above the well. They may see a puff of dust, and they will feel some ground motion.

Project Rulison is a joint government-industry experiment by Austral, the AEC, the Department of Interior, and CER Geonuclear Corporation, acting as Program Manager under contract to Austral.

## FACT SHEET--STEMMING FOR PROJECT RULISON NUCLEAR DEVICE

The Project Rulison nuclear device rests at the bottom of a mile and a half deep drillhole which has been stemmed--that is, backfilled, to contain radiation from the detonation.

Total depth of emplacement hole--8,442.5 feet.

Diameter of hole--15 inches.

Inside diameter of hole casing--9 3/4 inches.

Stemming began--1 p.m., Friday, August 15.

Stemming completed--12:45 p.m., Friday, August 29.

Stemming materials--1) "Pea gravel" (so-called from the size of the particles) specially sized and dried at the AEC's Nevada Test Site and shipped to Project Rulison.  
2) A mixture of bentonite (a special clay) and sand.

Arrangement of materials--90-foot thick layers of pea gravel alternating with 10-foot thick layers of sand-bentonite mixture.

Stemming rate--25 feet per hour at the beginning, increased to 100 feet per hour by completion (controlled by pouring materials into loading hopper from boxes containing one cubic foot).

Total volume of stemming materials--4100 cubic feet.

Total weight of stemming materials--approximately 165 tons.

The Rulison emplacement hole is the deepest ever drilled in the United States for a nuclear detonation. It is twice as deep as a hole drilled at the AEC's Nevada Test Site for the recent, successfully contained detonation of a device 30 times more powerful than Rulison's.



JOI 69

PROJECT RULISON  
Joint Office of Information  
Grand Valley, CO 81635

September 5, 1969

Telephone: 303-285-7566

FOR IMMEDIATE RELEASE

Project Rulison, postponed twice because of unfavorable winds, may be delayed further because of weather, U.S. Atomic Energy Commission Test Manager, Robert H. Thalgott, announced.

Rulison is a 40-kiloton underground nuclear detonation experiment designed to test the economic and technical feasibility of freeing natural gas by fracturing rock in which the gas is tightly trapped.

The project was originally scheduled for 3 p.m. Thursday, September 4, and was postponed for two consecutive 24-hour periods. It is now scheduled for 3 p.m. Saturday, September 6. However, Thalgott said, unless the weather prediction tonight indicates a better than 50-50 chance of favorable weather Saturday, the project will be postponed at least 48 hours to avoid detonation on Sunday.

Thalgott emphasized that weather delays were not unusual in underground tests. He recalled that the Project Salmon test in Mississippi in 1964 was repeatedly postponed. Salmon was fired October 22--30 days after the originally scheduled date of September 22.

The AEC simply does not take chances with public safety, he said. By waiting for the right wind speed and direction, the AEC can ensure to the maximum extent possible that potential exposures to radiation would be the lowest possible in case of an accidental release of radioactivity to the atmosphere.

He stressed that the AEC does not expect Rulison to vent radioactivity to the atmosphere because the explosive is 8,430 feet underground, which is six times deeper than necessary to contain the nuclear explosion. None of the underground nuclear tests conducted below 2,000 feet has ever vented, he said.

Even if the weather prediction tonight should prove favorable, he said the weather would be reviewed again on Saturday morning. Unless the morning weather report confirmed the predictions, the detonation would be postponed until Monday at the earliest. He added that unless the detonation is postponed, the AEC Test Manager's Advisory Panel would review the weather continuously throughout the day and that the detonation could be delayed even minutes before the scheduled detonation time of 3 p.m.

The Test Manager's Advisory Panel serves on every underground nuclear detonation test. Of the more than 250 announced tests, the panel has recommended delays or postponements on a very high percentage of the tests because of unfavorable weather conditions, he said.

Project Rulison is a joint experiment sponsored by the Austral Oil Company, Incorporated, of Houston, Texas, the U.S. Atomic Energy Commission, and the Department of the Interior.

## RULISON GAS EXPERIMENT CONDUCTED IN COLORADO

The U.S. Atomic Energy Commission detonated a nuclear explosive deep underground in western Colorado this afternoon in a natural gas stimulation experiment.

Called Project Rulison, the explosive was fired 8,430 feet beneath the surface at 5 p.m. EDT about 40 miles northeast of Grand Junction. There was no release of radioactivity. Radiation and health safety experts will continue to monitor the experimental area.

The nuclear explosive had a design yield of 40 kilotons (equivalent to 40,000 tons of TNT). The explosion was expected to create an underground chimney of broken rock 160 feet in diameter and about 370 feet high.

Project Rulison is one in a series of experiments designed to determine the technical and economic feasibility of enhancing the recovery of natural gas through the use of nuclear explosions.

It is the second joint government-industry experiment in the AEC's Plowshare Program to develop peaceful uses of nuclear explosives. The experiment is expected to cost about \$6.5 million.

UNITED STATES  
ATOMIC ENERGY COMMISSION  
Nevada Operations Office  
Post Office Box 14100  
Las Vegas, NV 89114

September 19, 1969

Office of Public Affairs  
2753 South Highland  
Telephone: 734-3851

FOR IMMEDIATE RELEASE

Preliminary ground motion analyses from the Project Rulison underground nuclear detonation near Grand Valley, Colorado, on September 10, 1969, indicate that the explosive achieved its design yield of 40 kilotons--the energy equivalent of 40,000 tons of TNT.

Preliminary examination of ground motion information recorded on seismographs indicates that the shock wave intensities conformed generally to the patterns predicted before the detonation.

Complaints of damage to property as a result of the detonation totaled 172 on September 19. Of that number, 25 formal claims for payment have been filed with the Rulison Claims Office in Grand Valley.

Eighteen of the 25 claims have been paid, the largest of which was for \$887.26 for damage to a concrete block home and a 20-foot by 20-foot concrete block garage. Damage consisted of interior plaster cracks and exterior masonry cracks. This is the largest claim to date.

Rulison is the second natural gas stimulation experiment in the AEC's Plowshare Program to develop peaceful uses for nuclear explosives. It was sponsored jointly by Austral Oil Company, Inc., of Houston, Texas, the Atomic Energy Commission, and the U.S. Department of Interior. CER Geonuclear Corporation of Las Vegas was the Program Manager for Austral.

NV-69-131

UNITED STATES  
ATOMIC ENERGY COMMISSION  
Nevada Operations Office  
Post Office Box 14100  
Las Vegas, NV 89114

September 26, 1969

Office of Public Affairs  
2753 South Highland  
Telephone: 734-3851

FOR IMMEDIATE RELEASE

Special Achievement Certificates and cash awards were presented by the Atomic Energy Commission to nine employees of the Nevada Operations Office for their contributions to the successful completion of two underground nuclear tests--Projects Rulison and Jorum. The awards were made by NVOO Manager Robert E. Miller at a reception held recently at Caesars Palace in Las Vegas.

Awards for outstanding performance on Project Rulison, a Plowshare experiment which took place September 10 near Grand Valley, Colorado, went to Robert H. Thalgott, Test Manager; James B. Cotter, Project Engineer, Engineering Division; Frank D. Cluff, Safety Officer, Office of the Test Manager; Thomas O. Fleming, Chief Counsel; Eugene H. Freeman, Planning Analyst, Plans Division; Richard A. Johnson, General Engineer, Effects Evaluation Division; David F. Miller, Information Officer, Office of Public Affairs; and Paul J. Mudra, Chief, Off-Site Operations Branch, Operations Division.

The award for outstanding performance on an underground nuclear test called Jorum, which took place at the Nevada Test Site on September 16, went to William W. Allaire, Deputy Test Manager.

UNITED STATES  
ATOMIC ENERGY COMMISSION  
Nevada Operations Office  
Post Office Box 14100  
Las Vegas, NV 89114

October 1, 1969

Office of Public Affairs  
2753 South Highland  
Telephone: 734-3851

(NOTE TO EDITORS AND CORRESPONDENTS: The following information was released by Austral Oil Company, Incorporated, in Denver, Colorado, and Houston, Texas, on Tuesday, September 30, 1969.)

Continuous postshot observations made at the surface of the Rulison emplacement hole indicate that the 40-kiloton nuclear explosive successfully detonated 8,430 feet below the surface on September 10, near Grand Valley, Colorado, has released natural gas from the tight Mesaverde formation.

A shut-in pressure of 1,850 pounds per square inch gauge (psig) was observed at the wellhead on September 29, and, as expected, such pressure continues to increase slowly. Wellhead pressure data have been under continuous observation since detonation. It is estimated that this shut-in pressure will reach approximately 2,400 psig by the time the reentry operations are commenced, now planned for March, 1970. No flaring of the gas will take place for at least six months after the detonation.

The gas is completely contained by the specially designed wellhead equipment which has been tested in accordance with the American Petroleum Institute (API) standards to a pressure of 6,000 psig.

Engineers connected with the project are encouraged by the pressure data which is an indication that the nuclear explosion has stimulated the gas reservoir. These observations in themselves are not proof of success.

Many months of production testing will be required to determine the total success of the project.

Project Rulison was the second underground detonation of a nuclear explosive in a gas reservoir and is the deepest such detonation to date. This experiment was jointly sponsored by Austral Oil Company, Incorporated, of Houston, the Atomic Energy Commission, and the Department of the Interior. CER Geonuclear Corporation acted as Program Manager.

UNITED STATES  
ATOMIC ENERGY COMMISSION  
Nevada Operations Office  
Post Office Box 14100  
Las Vegas, NV 89114

October 28, 1969

Office of Public Affairs  
2753 South Highland  
Telephone: 734-3851

FOR IMMEDIATE RELEASE

The Project Rulison Damage Claims Office at 143 West First Street, in Grand Valley, Colorado, will close at 5 p.m. Friday, November 14, 1969. Claims for damage resulting from the Project Rulison underground nuclear detonation after that date will be processed by the General Adjustment Bureau, 1010 North Fifth Street, Grand Junction, Colorado 81501, telephone 242-6771. N. A. Radice of the GAB will be in charge of the Rulison claims.

The Claims Office opened in Grand Valley on September 11, one day after the 40-kiloton underground nuclear detonation experiment. Rulison is designed to test the technical and economic feasibility of increasing natural gas production by fracturing the rock in which the gas is tightly trapped.

Complaints of damage to property as a result of the detonation totaled 336 as of October 24. Of that number, 214 formal claims for payment have been filed with the Claims Office. One hundred eighty-four of the 214 claims have been paid for a total of \$37,694.02. The largest claim was \$28,100 for damage to the Busk-Ivanhoe Tunnel owned by the High Line Canal Company. The claim is being investigated.

Types of property and the number of claims for damage to each type as of October 24 were: chimneys, 95; plaster cracks, 129; cracked wells or cisterns, 25; exterior walls, 46; foundations, 54; household items, 12; and miscellaneous property, 88. Of the 336 complaints or claims, 108 were for damage to more than one type of property.

After investigations by claims adjusters, 54 complainants have been advised that their claims of damage were not attributable to Rulison.

NV-69-157

UNITED STATES  
ATOMIC ENERGY COMMISSION  
Nevada Operations Office  
Post Office Box 14100  
Las Vegas, NV 89114

November 24, 1969

Office of Public Affairs  
2753 South Highland  
Telephone: 734-3851

FOR IMMEDIATE RELEASE

Three additional documents will be added in the near future to the Project Rulison scientific and technical reports files established for public use in three western cities. The documents are: "Radioactivity in the Hydrologic Environment--Project Rulison Final Pre-Shot Report"; "Project Rulison Planning Directive"; and Project Rulison Definition Plan."

The Project Rulison open files were established in September 1969, in Denver, Las Vegas, and Bartlesville, Oklahoma. The files are located at:

University of Nevada, Las Vegas  
Attn: Library Document Section  
4505 Maryland Parkway  
Las Vegas, NV 89109

Contact Alice Brown or E. Curley  
Area Code 702, 736-6111, Ext. 279

U.S. Bureau of Mines  
Office of Mineral Resource Evaluation  
Attn: Open File  
Library, Building 20  
Denver Federal Center  
Denver, CO 80225

Contact Sam Sheppard  
Area Code 303, 233-3611, Ext. 6521

U.S. Bureau of Mines  
Bartlesville Petroleum Research Center  
Attn: Open File  
Virginia and Cudahy Streets  
Bartlesville, OK 74003

Contact V. V. Hutchison  
Area Code 918, 336-2400, Ext. 228

In addition to the three additional documents, all Rulison final reports will be placed in the files. Each file location has a listing of the Rulison final reports indicating the title, author, and approximate date the reports are scheduled to be made available.

Copies of the well logs made during the Rulison exploratory hole and emplacement hole drilling may be purchased from: Birdwell, Division of Seismograph Service Corporation, Post Office Box 1590, Tulsa, Oklahoma 74102; or Rocky Mountain Well Log Service Company, 1753 Champa Street, Denver, Colorado 80202.

A list of documents now in the Rulison files is attached.

LIST OF DOCUMENTS IN THE RULISON FILES

PNE-R-1 "Project Rulison," NVP-2, JOI.

PNE-R-2 "Geology and Hydrology of the Project Rulison Exploratory Hole, Garfield County, Colorado," (USGS-474-16) April 4, 1969.

PNE-R-3 "Pre-event Bioenvironmental Safety Survey and Evaluation--Project Rulison," (BMI) May 23, 1969.

PNE-R-4 "Effects Evaluation for Project Rulison," NVO-43.

PNE-R-5 "Predictions of Seismic Motion and Close-In Effects," NVO-1163-180, (ERC).

PNE-R-6 "Records of Selected Wells and Springs in the Rulison Project Area, Garfield and Mesa Counties, Colorado," (USGS-474-40).

PNE-R-8 Inspection Report, "Emplacement and Cementing of Hole 25-95A (Emplacement Hole) Hayward Well in Garfield County, Colorado," (F&S).



UNITED STATES  
ATOMIC ENERGY COMMISSION  
Nevada Operations Office  
Post Office Box 14100  
Las Vegas, NV 89114

April 1, 1970

Office of Public Affairs  
2753 South Highland  
Telephone: 734-3851

FOR IMMEDIATE RELEASE

Major preparations for reentry operations at Project Rulison, six miles south of Grand Valley, Colorado, started today, April 1. Participants in the Rulison project are the Austral Oil Co., Inc., the U.S. Atomic Energy Commission, and the Bureau of Mines of the U.S. Department of the Interior. Drilling is scheduled to begin April 15, with reentry into the explosion-induced chimney expected about mid-June.

The 40-kiloton nuclear detonation for Project Rulison took place 8,425 feet below the surface of the site on September 10, 1969, and formed the rubble-filled chimney in the Mesaverde gas-bearing sandstone formation. The experiment is to study the feasibility of using a nuclear explosion to free large quantities of natural gas trapped in the formation.

The schedule for the reentry program was agreed to by the project participants following a ruling by Chief Judge Alfred A. Arraj of the Colorado Federal District Court on lawsuits challenging the Rulison operations. Judge Arraj denied injunction requests which sought to prevent flaring or burning of the natural gas released from the cavity. The flaring will dispose of gas flowed from the well to measure the quantity of gas produced and to study the quality of the gas, including radioactivity.

In denying the injunction requests, the District Court found that the proposed flaring of gas from the Rulison chimney has not been shown to present a danger to life, health, or property of the plaintiffs, or any others similarly situated. The court also held that it would retain jurisdiction over the litigation during the flaring period.

Chimney entry will be through the site evaluation well, which is about 300 feet away from the emplacement hole. Plans are to redrill the entry hole to 6,500 feet, and then angle drill to the chimney which is expected to be reached at about 8,000 feet.

After the chimney is penetrated and the production testing and radiation monitoring equipment are checked, a comprehensive gas testing program of the nuclear-stimulated reservoir is planned during an eight- to twelve-month period. Gas from the well will be flowed intermittently and only when necessary for the desired testing. Atomic Energy Commission and Los Alamos Scientific Laboratory scientists will direct continuous monitoring of the gas for radioactivity as it is produced and burned. The AEC is responsible for radiological safety. Production testing of the well will be under the direction of the Bureau of Mines and CER Geonuclear Corp., project manager for Austral.

In preparing for the reentry operation, U.S. Public Health Service crews will be in the area to take background radiation measurements and to locate several sites for installation of radiation sampling equipment. Eberline Instrument Corporation will install on-site radiation monitoring equipment. Austral will prepare the drilling site for the rig.

NV-70-44

UNITED STATES  
ATOMIC ENERGY COMMISSION  
Nevada Operations Office  
Post Office Box 14100  
Las Vegas, NV 89114

April 29, 1970

Office of Public Affairs  
2753 South Highland  
Telephone: 734-3851

FOR IMMEDIATE RELEASE

Project Rulison personnel will brief Western Slope civic leaders who have been invited to a meeting on Project Rulison and a visit to the project site by Grand Valley Mayor Ruth Keisler on behalf of her city council. The briefing will be at 1:45 p.m. Wednesday, May 6, in the Grand Valley School.

Speakers will be Robert H. Thalgott, Test Manager for the Atomic Energy Commission's Nevada Operations Office; Will Frank, Senior Vice President for Austral Oil Company, Inc.; and Dr. John Emerson of the Colorado Department of Public Health. Thalgott will talk on the safety precautions to be taken during drilling into the Rulison natural gas formation and during the natural gas production testing program, which calls for burning the produced gas from a flare stack at the site. Frank will talk about the drilling program and Austral Oil Company's plans. Dr. Emerson will review the Colorado Health Department's activities in connection with the project.

Invited to attend the briefing and site tour, which will take place after the briefing, are: State Representatives T. John Baer, Jr., Charles E. McCormick, and John D. Vanderhoof; the mayors and city councils of Rifle, DeBeque, Collbran, Silt, and Mesa; the mayors and one councilman each from Aspen, Carbondale, Grand Junction, Glenwood Springs, Meeker, New Castle, Rangely, Palisade, and Basalt; and the commissioners from Mesa and Garfield Counties.

Thalgott, Frank, and Emerson also will discuss the same subjects at a public meeting for persons living in the Rulison area on Thursday, May 7, at 8:00 p.m. at the Grand Valley School.

UNITED STATES  
ATOMIC ENERGY COMMISSION  
Nevada Operations Office  
Post Office Box 14100  
Las Vegas, NV 89114

May 6, 1970

Office of Public Affairs  
2753 South Highland  
Telephone: 734-3851

NOTE TO EDITORS AND CORRESPONDENTS: The following is a progress report on Project Rulison. These reports will be issued periodically as noteworthy changes take place in the reentry drilling program and the natural gas production testing program that will follow drilling.

Drilling of cement from the exploratory hole casing at the Project Rulison site near Grand Valley, Colorado, had reached 6,520 feet as of noon, Tuesday, May 5, 1970. Operations were under way to mill out the casing liner and milling was continuing at about 5,870 feet. Drilling to penetrate the zone of broken rock (chimney) in the natural gas formation fractured by a nuclear explosion started on April 28.

Neither natural gas pressure nor radioactivity had been encountered as of Tuesday, although both are expected when the drilling reaches the chimney area at about 8,000 feet. Project engineers expect drilling to be completed late in June. Then, after sampling and analysis of the natural gas with highly sensitive radiation detection instruments, production testing will begin.

The gas produced during the production testing will be monitored constantly for radioactivity. In conformance with the Atomic Energy Commission and Federal Radiation Council standards, the gas, as it is produced, will be flared (burned) from a stack at the Rulison site.

Rulison is a joint government-industry project to determine the technical and economic feasibility of stimulating natural gas production by nuclear fracturing of rock formations that cannot otherwise be produced. The project participants are Austral Oil Company, Inc., Houston; the Atomic Energy Commission; and the Department of the Interior's Bureau of Mines.

UNITED STATES  
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Las Vegas, NV 89114

May 28, 1970

Office of Public Affairs  
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As a service to the public, the Nevada Operations Office of the U.S. Atomic Energy Commission has placed documents relating to Project Rulison in the school libraries at Grand Valley and DeBeque, and the library in the Cedar-edge City Hall.

The documents include the complete transcript of the Rulison trial, which took place in the U.S. District Court in Denver in January, 1970, with the exception of the supporting documents introduced as evidence by both sides.

Other documents placed in the libraries are: the court decision by Denver U.S. District Court Chief Judge Alfred A. Arraj, nontechnical booklet called "Project Rulison," the "Project Rulison Post-Shot Plans and Evaluations," "Reports Currently Available in Plowshare Open File," and a full set of a series of booklets called "Understanding the Atom."

With the exception of the trial transcript, which consists of eight volumes, all the documents may be checked out of the library at the discretion of the librarian. The trial transcript will be treated as a reference work and may be read only in the library. The trial transcript and court decision are presently available to interested persons at the U.S. District Court in Denver where they are a matter of public record and may be purchased from the court clerk.

Documents listed in "Reports Currently Available in Plowshare Open File," which includes many highly technical reports, may be purchased from the Clearing House for Federal Scientific and Technical Information, National Bureau of Standards, U.S. Department of Commerce, Springfield, Virginia 22151. Reports available from the Clearing House include "Project Rulison" and "Project Rulison Post-Shot Plans and Evaluations." The Rulison trial decision will be available soon from the Clearing House.

Up to three different booklets in the "Understanding the Atom" series may be ordered without charge from the USAEC, Post Office Box 62, Oak Ridge, Tennessee 37830.

NV-70-

UNITED STATES  
ATOMIC ENERGY COMMISSION  
Nevada Operations Office  
Post Office Box 14100  
Las Vegas, NV 89114

June 12, 1970

Office of Public Affairs  
2753 South Highland  
Telephone: 734-3851

FOR IMMEDIATE RELEASE

Drilling at the Project Rulison site near Grand Valley, Colorado, has reached a depth of 7,159 feet as of noon Thursday, June 11, 1970. Penetration of the chimney (the zone of broken rock created in a natural gas formation by a 40-kiloton nuclear detonation in September 1969) is expected at about 8,000 feet. Penetration is expected to take place late in June or early July.

Drilling is taking place in the project's exploratory hole some 300 feet southeast from the hole that was used to emplace the nuclear explosive in the gas-bearing rock about 8,400 feet underground. Angle drilling to cross the lateral distance to the chimney began at a depth of 6,468 feet after a 5.5-inch casing liner was milled from the exploratory hole. When drilling reaches 7,600 feet, a new casing liner will be cemented in place from about 6,000 to 7,600 feet.

Production testing of gas liberated from the fractured rock is expected to begin after the chimney is encountered and gas samples are analyzed for radioactivity. Plans call for the gas to be flared (burned) from a stack at the Rulison site once production testing begins. The gas will be monitored as it is produced by highly sensitive radiation detection instruments to assure conformance with Atomic Energy Commission health and safety standards, which are the same as those set by the Federal Radiation Council.

Project Rulison is a joint experiment of the AEC, Austral Oil Company, Inc., of Houston, and the Department of the Interior's Bureau of Mines to determine the technical and economic feasibility of stimulating natural gas production.

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Las Vegas, NV 89114

July 29, 1970

Office of Public Affairs  
2753 South Highland  
Telephone: 734-3851

(NOTE: The following was issued in Grand Junction, Colorado, on July 28.)

Drilling at Project Rulison, near Grand Valley, Colorado, penetrated a zone of fractured rock at a drillstring depth of 8,270 feet (8,152 feet vertical) which resulted in a continuing loss of drilling mud to the formation. This depth is about 280 feet above the original detonation depth of 8,431 feet. Drilling was continued into the fractured zone to assure an adequate flow of gas from the chimney area, and was stopped at a drillstring depth of 8,354 feet (8,236 vertical). Two bubbles of natural gas were observed at the surface, one of which contained a small amount of radioactivity that pulsed the meter to a rate of one-tenth of a milliroentgen per hour at the wellhead.

During the next six days, personnel at the site are expected to emplace three and one-half-inch diameter production tubing in the drillhole, which has been lined with steel casing to 7,600 feet, install a seal (production packer) between the casing and the tubing at about 7,500 feet, and install control valves (called a Christmas Tree) at the top of the wellhead. The drilling equipment is expected to be removed during the subsequent four-day period.

Final preparations for natural gas production testing of the well will be made during the next ten-day period. Preparations include installation of a three-phase separator (which removes water and hydrocarbon condensates comparable to low-grade gasoline from the natural gas) and complete safety and functional checks of the gas flow system and radiation monitoring systems.

The next phase will consist of controlled flaring of gas under varying weather conditions to establish environmental control procedures. About twenty million standard cubic feet of natural gas is expected to be produced during a ten-day period. The flaring will involve a high rate of release of gas from the well for short periods of two to four hours under careful radiation control monitoring to assure compliance with the health and safety standards set by the Federal Radiation Council (FRC).

Eberline Instrument Corporation will conduct the on-site monitoring effort under the direction of the Los Alamos Scientific Laboratory, which is operated for the AEC by the University of California. Personnel from the U.S. Public Health Service's Southwestern Radiological Health Laboratory will conduct radiation monitoring surveys of the Rulison environs, including sampling of air, water, and vegetation.

A waiting period of up to 20 days after calibration flaring is planned to permit gas pressure to stabilize in the well. After the waiting

period, continuous high-rate production testing is planned for about six days. Daily production during the high-rate testing period is estimated to be as high as twenty million standard cubic feet per day. Concentrations of radioactivity in the Rulison environment during the entire production testing program are expected to be well below the FRC radiation protection guidelines. Production testing at various rates is planned for the next several months.

Project Rulison is a joint experiment of the Austral Oil Company and the Atomic Energy Commission to test the technical and economic feasibility of freeing natural gas from a tight formation by nuclear stimulation.



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(NOTE: The following was telephoned to Colorado news media at 10 p.m. Friday, July 31, 1970. Colorado news media were immediately informed after the sample flaring, which took place shortly after 8 p.m. Saturday, August 1, 1970, that 147,000 standard cubic feet of natural gas had been flared during a 29-minute period.)

Project Rulison scientists and engineers plan to flare (burn) something more than 50,000 standard cubic feet of natural gas in the next few days to obtain samples of the gas for detailed radiochemical analysis.

The limited flaring will enable Atomic Energy Commission and U.S. Public Health Service (USPHS) scientists to obtain representative samples of the gas in the chimney prior to the calibration flaring now planned for about mid-August. The chimney is a broken rock zone in the natural gas formation that was formed by the 40-kiloton nuclear detonation some 8,000 feet underground last September.

Calibration flaring calls for burning up to a total of 20 million standard cubic feet of natural gas. The gas will be released during two- to four-hour periods for several days to permit environmental sampling by the PHS. Environmental samples (air, water, and vegetation) will be analyzed to assure compliance with the health and safety standards set by the Federal Radiation Council.

The detailed laboratory analysis obtained from the planned sample flaring will enable project scientists to plan the later calibration flaring with greater accuracy because they will have precise data on the radioactivity in the gas rather than predicted estimates.

The sample flaring depends upon completing the connections of the gas production tubing with the production packer and the Christmas Tree. The production packer is a seal about 7,500 feet underground that prevents escape of gas to the surface. The Christmas Tree is a system of control valves at the surface that regulates the flow of gas. The final connections are expected to be completed sometime midday, Saturday.

A limited number of Public Health Service personnel will be at their environmental sampling stations during the sample flaring. Little, if any, radioactivity is expected to be detected in the Rulison environs.

A small amount of krypton-85--a noble radioactive gas that does not combine with living matter--was released from drilling mud and flared Thursday night during installation of the production tubing in the drill hole. The installation involved flushing the drilling mud from the hole

with water and purging the water with nitrogen gas. Samples of the gas released from the mud were taken to the USPHS Southwestern Radiological Health Laboratory in Las Vegas, Nevada, for analysis. However, project scientists do not believe the samples will be representative of the gas in the chimney because of its filtration through the drilling mud and the small quantity of gas involved.

UNITED STATES  
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August 10, 1970

Office of Public Affairs  
2753 South Highland  
Telephone: 734-3851

Preliminary samples of natural gas taken from the Project Rulison well near Grand Valley, Colorado, on Saturday, August 1, 1970, show average concentrations of tritium and krypton-85 that are well below the protective action guidelines established for the project. The samples were analyzed by the U.S. Public Health Service (USPHS) at its Southwestern Radiological Health Laboratory in Las Vegas.

Three samples totaling about 17 standard cubic feet of gas were taken during the preliminary flowing and burning of some 147,000 standard cubic feet of natural gas at the Rulison site August 1. As expected, USPHS instruments downwind and in other areas around the Rulison site did not detect anything other than background radioactivity during or after the preliminary burning operation. The concentrations of radioisotopes measured in the gas samples are well within limits to assure public health.

The gas sampling and analysis is part of the program to assure the health and safety of persons in the Rulison area during the planned production testing of the Rulison well. The production testing is designed to determine how much nuclear fracturing of the gas-bearing rock will increase gas production.

Data on the Rulison gas analysis will be on file for public inspection this week in the Project Rulison Open Files established in Las Vegas, Nevada; Bartlesville, Oklahoma; and Denver, Colorado. The average tritium concentration was about 0.00022 microcurie per cubic centimeter. The krypton-85 concentration averaged about 0.000114 microcurie per cubic centimeter. These concentrations are expected to be reduced manyfold when the gas that contains the radioactivity is flared and thus is combined with large volumes of oxygen. Still further reduction in concentrations of the radioactivity takes place when the flared gas is diluted and dispersed by winds in the atmosphere.

Though the first samples are preliminary in nature, project participants believe they are an encouraging indication that concentrations of radioactivity in the chimney gas will prove to be less than predicted.

NV-70-83

UNITED STATES  
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August 11, 1970

Office of Public Affairs  
2753 South Highland  
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FOR IMMEDIATE RELEASE

The U.S. Atomic Energy Commission's Nevada Operations Office will reopen the Project Rulison Claims Office at 143 First Street in Grand Valley, Colorado, on Monday, August 31, 1970, ten days before the final day for filing claims. The legal deadline is at the end of the day September 10, 1970. Office hours will be 8 a.m. to 6 p.m., Monday through Friday, and 8 a.m. to 1 p.m. on Saturday. The telephone numbers will be 285-7527 and 285-7528.

The Nevada Operations Office Manager, Robert E. Miller, said the office was being reopened as a service to the public since claims for damage resulting from underground nuclear detonations must be filed under current law within one year of the date of the detonation. The 40-kiloton Project Rulison detonation occurred 8,400 feet underground on September 10, 1969, some six and one-half miles from Grand Valley.

The Rulison Claims Office was opened in Grand Valley on September 10, 1969, and remained open until November 14, 1969, when damage claims processing was transferred to the General Adjustment Bureau, Inc. (GAB), office at 1010 North First Street in Grand Junction, Colorado. The GAB receives complaints of damage, investigates complaints and formal claims, and recommends claims settlements to the Atomic Energy Commission. The Grand Junction GAB office will continue to process claims until the office in Grand Valley reopens.

Project Rulison is a joint experiment with Austral Oil Company, Inc., of Houston, Texas, the U.S. Atomic Energy Commission, and the Department of the Interior's Bureau of Mines. Its purpose is to test the technical and economical possibility of freeing natural gas from a tight formation by nuclear explosive fracturing of the rock.

NV-70-87

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Office of Public Affairs  
2753 South Highland  
Telephone: 734-3851

(NOTE: The following announcement was given orally to Colorado news media at 3:30 p.m. MDT, Tuesday, August 18, 1970, in response to inquiry.)

A clogged gas line caused a valve to close, stopping the first safety calibration flaring of gas from the Rulison well. The test started at 11:37 a.m. and ended 20 minutes later with a total production of 140,000 standard cubic feet of natural gas. The peak flow rate during the test reached 17 million cubic feet per day.

Drill cuttings, mud, and water clogged a line to the separator unit which caused a low-pressure sensor to activate an automatic cutoff valve which is part of an emergency system to turn off the flaring unit in the event of a problem.

A drilling well control unit (DWC) designed to remove particles from the gas line is being sent to the site by Austral Oil Company, the project's industrial sponsor. It is expected that the calibration flaring operation will resume early next week.

U.S. Public Health Service and Colorado Health Department radiation monitors were on station around the area to measure radioactivity released. One sample was obtained by a PHS aircraft flying over the flare. The sample will be analyzed in the Southwestern Radiological Health Laboratory in Las Vegas.

Radioactivity in the gas coming out of the well was similar to past measurements and was well below the radiation safety guidelines.

NV-70-88

UNITED STATES  
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August 19, 1970

Office of Public Affairs  
2753 South Highland  
Telephone: 734-3851

(NOTE: The following was issued to Colorado news media at 10:30 a.m. PDT today.)

Work is proceeding today toward installing equipment to separate drilling mud and drill cuttings from the natural gas produced at the Project Rulison well near Grand Valley, Colorado. The mud and cuttings clogged equipment in early gas flow tests this week, causing a pause in the flow experiments scheduled for this period.

During the flow periods, an estimated total of 140,000 cubic feet of gas was flared. Early estimates of radioactivity in the gas corresponded closely to that measured in natural gas analyzed a week earlier from the well, in which tritium and krypton-85 levels were well below the protective action guidelines established for the project. All radioactivity measurements in gas from the well so far have been well below the guidelines.

At the project, it is believed that equipment installation can be completed in a day or so and experimental flow tests resumed early next week.

NV-70-89

UNITED STATES  
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Post Office Box 14100  
Las Vegas, NV 89114

August 24, 1970

Office of Public Affairs  
2753 South Highland  
Telephone: 734-3851

(NOTE: This announcement was given orally to the news wire services in Denver at 8:30 a.m., August 23, 1970.)

Testing of the nuclear-stimulated well at Project Rulison near Grand Valley, Colorado, was resumed Saturday, August 22. An attempt was made to flow the well after installing an additional separator Friday to remove the drill cuttings that plugged the surface equipment on August 18.

Saturday's test, however, was halted after 46 minutes when an apparent restriction occurred in the well bore. The restriction is believed to be an accumulation of drill cuttings below the production packer set at 7,500 feet underground. No further testing of the well will take place until the restriction has been removed.

During Saturday's test, a total volume of about 193,000 standard cubic feet of gas was flared at a maximum rate of 11,300,000 standard cubic feet per day between 10:21 a.m. and 11:07 a.m. Radioactivity levels in the gas as it was produced Saturday were in the range measured during previous flarings--well below radiation safety guidelines.

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August 24, 1970

Office of Public Affairs  
2753 South Highland  
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(NOTE: The following announcement was given orally to Colorado news media at 2:30 p.m. PDT, Monday, August 24, 1970.)

Gas flaring at the Project Rulison well near Grand Valley, Colorado, will be delayed until an apparent obstruction in the well bore below the 7,500-foot level can be removed. Work to remove the obstruction, thought to be drill cuttings, is now underway and probably will take until late September to complete. Plans call for removing the production tubing and packer (seal) to clean out the well bore below 7,500 feet.

Gas was flowed from the well and flared (burned) on August 1, 18, and 22. Small volumes of gas were flared on other dates in connection with technical measurements and other operations. The obstruction, which apparently reduced gas flow rates, halted flaring operations twice, once on August 18, and again on August 22. Production rates, all achieved for brief periods, varied from 7.3 million standard cubic feet per day on August 1, to a maximum of 17 million standard cubic feet per day, which was achieved on August 18. The flow rate on August 22 was 11.3 million standard cubic feet per day.

To date, a total volume of 480,000 standard cubic feet of gas has been flowed and flared in an attempt to complete the well by blowing the drill cuttings and mud from the hole. Radiation levels measured in the gas prior to flaring have been well below the radiation operating limits established for the project.

No radioactivity from the flaring has been detected on the ground at the project site or the site's environs. However, U.S. Public Health Service aircraft with highly sensitive equipment did detect traces of radioactive gas (tritium) in the flare's plume (heated air) about two miles downwind during the August 18 flaring. Laboratory analysis showed the airborne tritium was less than one ten-thousandth of the appropriate radiation guides.



UNITED STATES  
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September 22, 1970

Office of Public Affairs  
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Telephone: 734-3851

FOR IMMEDIATE RELEASE

Recently completed radiochemical analyses of natural gas samples taken from the Project Rulison well indicate that approximately one-tenth of a gram of tritium is present in gaseous form in the cavity formed some 8,000 feet underground by the 40-kiloton nuclear detonation near Grand Valley, Colorado, in September, 1969.

The latest gas analyses were performed by the radiochemistry division of the Lawrence Radiation Laboratory at Livermore, California, which is operated by the University of California for the Atomic Energy Commission. The gas samples that were analyzed were taken on August 1, 1970, at 8:00, 8:24, and 8:30 p.m. while the well was flowing at the rate of 7.2 million standard cubic feet per day. Thirty thousand standard cubic feet had been released before the samples were taken.

The original prediction, made to assess the potential exposure to the public from flaring operations (burning the gas in the atmosphere as it is produced), was that one gram of tritium would be present in the gas and that most of that would be released during the flow tests. On the basis of measurements made of a small sample of gas taken at the top of the sealed emplacement hole in January 1970, the prediction was lowered to two-tenths of a gram. This prediction was made public during the trial in U.S. District Court in which the plaintiffs asked the court to stop the flaring operation.

The new samples, which should be more representative of the cavity gas, indicate that even this second prediction was twice too high. Predictions by project scientists of possible effects are purposely chosen to be conservative so the actual effect will be less than predicted and, therefore, well within safety guidelines.

The latest analysis shows the Rulison gas has a concentration of tritium almost four times smaller than that measured in the Gasbuggy experiment, a similar natural gas stimulation experiment that used a 26-kiloton nuclear detonation 4,240 feet underground in northwest New Mexico. The initial concentration of tritium in the Gasbuggy experiment was 20 microcuries per standard cubic foot. The corresponding number for Rulison gas is 5 microcuries. (A microcurie is a millionth of a curie, a measure of the number of radioactive atoms disintegrating per second.) Further improvements in tritium reduction may result from nuclear explosives especially designed for natural gas stimulation. A test of such an explosive is planned to take place at the Nevada Test Site early in 1971.

Flaring operations at the Project Rulison site were stopped on August 23, 1970, when an apparent obstruction in the well bore restricted the gas flow. Work is presently underway at the site to clean out the well bore. Flaring operations are expected to be resumed late this month or early in October.

NV-70-101

UNITED STATES  
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October 1, 1970

Office of Public Affairs  
2753 South Highland  
Telephone: 734-3851

FOR IMMEDIATE RELEASE

Flaring of natural gas at the Project Rulison well site is tentatively scheduled to resume Saturday, October 3. Gas from the well will be flared for a sustained period, possibly up to 24 hours, prior to resuming scheduled calibration flaring operations.

Flaring at Project Rulison was stopped on August 23, when an obstruction in the well bore restricted the gas flow. Work is being completed on a cleaning operation which was designed to establish better communication with the chimney produced by a 40-kiloton detonation about 8,400 feet underground at the site near Grand Valley, Colorado, in September 1969.

This flaring operation will be conducted to make sure the well is cleaned out before the calibration flaring operation starts. The well is connected to a drilling well control unit designed to separate material such as drilling mud, drill cuttings, liquids, and condensates from the gas as it comes from the well.

U.S. Public Health Service personnel will be at their environmental sampling stations during the flaring operation. Radioactive content of the gas is substantially lower than predicted.

Project Rulison is a joint experiment by Austral Oil Company, Inc., of Houston, Texas, the U.S. Atomic Energy Commission, and the Department of the Interior. Its purpose is to test the technical and economical possibility of freeing natural gas from a tight formation by nuclear explosive fracturing of the rock.

UNITED STATES  
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October 5, 1970

Office of Public Affairs  
2753 South Highland  
Telephone: 734-3851

(NOTE: This information was given to news media orally on October 5, 1970, in Grand Junction, Colorado.)

Flaring (burning) of natural gas from the Rulison well was started at 9:15 p.m. on Sunday and is scheduled to continue throughout today. A total of 6.67 million cubic feet of natural gas had been flared by 11:30 this morning. Radiation in the gas, primarily tritium and krypton, continued to be measured at about the same level as previously announced, a rate substantially lower than had been predicted.

The flaring is being conducted at various rates as part of the process necessary to complete the well. The U.S. Public Health Service, in cooperation with the Colorado State Health Department and the Lawrence Radiation Laboratory of the University of California at Livermore, is conducting a calibration operation to determine the radioactive content of the flared gas and its dispersal in the area around the well during varying weather and wind conditions. Additional calibration flaring operations will be conducted during the week. Data obtained during Monday's operation will be available on Wednesday after it has been analyzed at laboratories in Grand Junction, Las Vegas, Nevada, and Livermore, California.

Calibration data will be used to determine the effects of the radiation released by high-volume flaring during well production testing scheduled to start approximately three weeks after the completion of the calibration flaring operations.

An attempt was made to start the flaring at 7:05 a.m. on Sunday, but was stopped at 8:47 a.m. when expanding gas coming from the well caused a valve to freeze, making the installation of a heater necessary. Approximately 125,000 cubic feet of natural gas was flared during the morning period.

The natural gas was released by a 40-kiloton nuclear detonation about 8,400 feet below the surface of the site near Grand Valley, Colorado, on September 10, 1969. Project Rulison is a combined effort of the U.S. Atomic Energy Commission, Austral Oil Company of Houston, Texas, and the Department of the Interior to determine the feasibility of stimulating natural gas production using a nuclear detonation. It is part of the Flowshare Program to develop the use of nuclear explosives for peaceful purposes.

RADIO-TV MONITORING SERVICE, INC.  
3408 Wisconsin Avenue, N.W.  
Washington, DC 20016  
244-8682

PROGRAM: NBC Nightly News  
STATION OR NETWORK: NBC TV

DATE: October 7, 1970  
TIME: 6:30 p.m., EDT

RESULTS OF RULISON EXPERIMENT BECOMING KNOWN

FRANK McGEE: President Nixon signed a bill today to spend more than \$5 billion on public works, but he didn't like it. He said there is too much pork in this barrel. A lot of it is for flood control work, but this bill also gives the Atomic Energy Commission \$2 billion and puts up \$1 billion to help prevent water pollution.

FRANK McGEE: In Rulison, Colorado, the results of a nuclear experiment are becoming known, if not universally accepted. (FILM CLIP)

FRED BRIGGS: Project Rulison has been controversial since its inception a few years ago. The Atomic Energy Commission, in partnership with Houston's Austral Oil Company, decided to use an underground nuclear blast to raise a gigantic pocket of natural gas, 8,000 feet, in Battlement Mesa in western Colorado.

The explosion itself took place more than a year ago, but the gas was not tapped until recently. The main concern was, what would that gas be like? It was certain to be radioactive, but the question was, how radioactive?

This week, the AEC began burning the gas--burning it above ground, trying to find out about this. It was more than just learning how radioactive the gas was at the point of flurry. Samples had to be taken for miles around in the field and then analyzed because gas spreads and sometimes settles in pockets.

The preliminary verdict was that the gas was safe; that its radioactivity would have to increase 400 times or more before it would approach a level where it would be dangerous to anyone.

The skeptics and environmentalists say they're not surprised; that the AEC has a tendency to sound optimistic to minimize the dangers in all of its projects. Still, the AEC admits it will be another year before the gas can be approved for commercial use. Fred Briggs, NBC News, at Project Rulison in Colorado.

UNITED STATES  
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October 7, 1970

Office of Public Affairs  
2753 South Highland  
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(NOTE: The following was released to news media in the Colorado area on October 7, 1970)

Preliminary raw data from air samples taken during the Rulison flaring calibration operation indicate that the highest levels of radioactivity measured near populated areas are 300 to 400 times less than the maximum permissible concentration (MPC) of tritium and krypton established as a guideline for the general population by the Federal Radiation Council.

The MPC for tritium is 67,000 picocuries per cubic meter of air and for krypton is 100,000 picocuries per cubic meter of air.

Air samples were taken by radiation monitors from the U.S. Public Health Service, the Colorado State Health Department, and the Lawrence Radiation Laboratory at Livermore, California. The natural gas flaring and calibration operation at the well was conducted from 9:15 a.m. Sunday, October 4, until 5 p.m. Monday, October 5.

Some samples were counted in the field. Others were being sent to home laboratories for more complete analyses. Final results of the analyses will be available in about two weeks and will be placed in the Project Rulison Open Files in Denver, Bartlesville, Oklahoma, and Las Vegas, Nevada. The flaring, which was stopped at 5 p.m. on Monday for equipment repair and adjustment, was resumed Tuesday at 2:05 p.m. As of 8 a.m. today, 10.89 million cubic feet of natural gas had been flared at rates ranging from 2 million cubic feet per day to about 16 million cubic feet per day.

Flaring calibration operations, to determine dispersion characteristics of the slightly radioactive water vapor given off during the flaring or burning of the natural gas from the Rulison well, were resumed this morning and will be completed this afternoon. Work proceeded during the current storm.

The gas is from the well 8,340 feet deep below the surface of the Project Rulison site near Grand Valley, Colorado. It is in a chimney produced by a 40-kiloton nuclear detonation on September 10, 1969, in a project to determine the feasibility of stimulating a natural gas well with a nuclear explosive. Project Rulison participants are Austral Oil, Inc., of Houston, Texas, the Atomic Energy Commission, and the Department of the Interior.

UNITED STATES  
ATOMIC ENERGY COMMISSION  
Nevada Operations Office  
Post Office Box 14100  
Las Vegas, NV 89114

October 23, 1970

Office of Public Affairs  
2753 South Highland  
Telephone: 734-3851

(NOTE: The following was given in response to inquiry by Austral Oil Company in Houston, Texas, and the AEC's Nevada Operations Office in Las Vegas, Nevada, on October 22, 1970.)

Tritium radiation levels in the air around the Project Rulison well during the natural gas calibration flaring operation October 4-7, 1970, ranged from background to about one four-hundredth of the Radiation Concentration Guide (RCG) near communities around the site located near Grand Valley, Colorado. No radioactivity above background has been found in streams and drinking water in the area.

Sufficient data has been obtained on the amount and dispersion of radioactivity released in water vapor by the flaring (burning) during different weather conditions to ensure that the planned production testing of the well can be conducted safely. Production testing is scheduled to start October 26.

One additional calibration operation may be conducted during the production testing period. This would provide additional data on an early morning downhill drainage wind condition at a flaring rate of 5 million cubic feet per day.

The production test flaring will be conducted to determine the effective chimney and fracture volume, the long-term production characteristics of the gas reservoir, and the production capability of the well. Starting October 26, it is planned that the well will be flared for six days at a rate of 20 million cubic feet per day, shut down for 20 days, flared for 16 days at a rate of 10 million cubic feet per day, shut down for 20 days, and flared for 90 days at a rate of 5 million cubic feet per day.

The natural gas is from gas-bearing rock fractured by a 40-kiloton nuclear explosive detonated about 8,400 feet below the surface of the site on September 10, 1969. Project Rulison is a Government-industry experiment to determine the feasibility of stimulating production from a low-permeability, gas-bearing formation using a nuclear detonation to fracture the rock. It is part of the AEC's Plowshare Program to develop peaceful uses for nuclear explosions. Project participants are Austral Oil Company, Inc., the AEC, and the Department of the Interior.

The flaring calibration was conducted to ensure public safety during the production testing of the well in a variety of weather conditions. About 12 million cubic feet of gas were flared during the calibration operation at rates varying from 2 million cubic feet per day to about 16 million cubic feet per day.

October 23, 1970

The gas burned with a clear, blue flame. The plume of heated air rising above the flaring stack was tracked as it was dispersed in the air by a U.S. Public Health Service monitor aircraft. As the burned gas approached ground level, samples were obtained by mobile radiation monitors dispatched to the scene by radio. Permanent monitoring stations in the area also collected air samples before, during, and after the flaring periods. The calibration continued during the heavy snowstorm that covered the area on October 7.

Air samples were taken and analyzed by the U.S. Public Health Service, the Lawrence Radiation Laboratory (Livermore, California), and the Colorado State Health Department. The resulting data from each laboratory were cross-checked to ensure accuracy. Complete calibration data are available to the public in the Project Rulison Open Files in Denver, Bartlesville, Oklahoma, and Las Vegas, Nevada.

Radiation concentration guides have been developed for tritium and other radioisotopes based on exposure guides developed by the Federal Radiation Council, the International Commission on Radiation Protection, and the National Council for Radiation Protection. These are established on the basis of continuous exposure to the concentrations specified.

The radiation concentration guide for tritium is 67,000 picocuries per cubic meter of air. During the calibration flaring, the highest tritium measurement obtained near Grand Valley was 50 picocuries per cubic meter of air or one one-thousandth of the RCG; the highest measurement obtained near Rifle was 160 picocuries per cubic meter of air or one four-hundredths of the RCG. These measured concentrations were obtainable only during the passage of the plume, which varies with wind direction.

A curie is a quantity of radioactivity described by the number of atoms disintegrating per second of any given radioactive substance. A picocurie is one-millionth of one-millionth of a curie--or 2.22 disintegrations per minute.



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November 3, 1970

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FOR IMMEDIATE RELEASE

The first phase of production test flaring of natural gas from the Project Rulison well was completed today at 2:17 p.m. MST when the well was shut in. A total of 109.456 million cubic feet of natural gas was flared at high rates averaging about 15 million cubic feet per day during the test period which started October 26. Wellhead pressure was 2,246 pounds per square inch when the test started and dropped to 1,200 psi at shut in.

The natural gas is from a chimney of broken rock formed by a 40-kiloton nuclear detonation on September 10, 1969, about 8,400 feet below the surface of the Project Rulison site near Grand Valley, Colorado. The production tests are being conducted to determine the effective chimney and fracture volume, the long-term production characteristics of the gas reservoir, and the production capability of the well.

The well will be shut down for about 20 days, or until pressure builds up sufficiently to allow starting the next segment of the production testing program. Present plans for completion of the program are to flare for 16 days at a rate of 10 million cubic feet per day, shut down for about 20 days, and flare for 90 days at a rate of 5 million cubic feet per day. Production test results will not be known until all data have been analyzed.

Project Rulison is a Plowshare Program experiment to determine the feasibility of stimulating production from a low-permeability, gas-bearing formation using a nuclear detonation to fracture the rock. Project participants are Austral Oil Co., Inc., the U.S. Atomic Energy Commission, and the Department of the Interior.

The production test flaring was started after a calibration flaring test had been conducted by the AEC to determine that radioactivity released by the flaring would not endanger public health or safety. The radioactivity released by the flaring was well below the radiation concentration guidelines.

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December 2, 1970

Office of Public Affairs  
2753 South Highland  
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(NOTE: The following was released to Colorado news media at 8:30 a.m. PST on November 30, 1970.)

Production test flaring is scheduled to be resumed at the Project Rulison well on December 1. Natural gas from the nuclear-stimulated well near Grand Valley, Colorado, will be flared at a rate of 5 million cubic feet per day for up to 20 days.

The original schedule was for the second production flaring test to be at a rate of 10 million cubic feet per day for 16 days. The change is being made to provide additional downhole pressure and temperature data that was not obtained during the October 23 through November 3 flaring tests.

The current flaring operation will be conducted with pressure and temperature measuring devices downhole. Flaring at the desired rate is expected to provide data necessary for reservoir evaluation.

During the flaring period, radiation surveillance will be maintained for air and water in the area around the site by the U.S. Public Health Service. Radiation released during the flaring is expected to remain at about the same level as for previous flarings, well below the radiation concentration guidelines.

The Project Rulison 40-kiloton nuclear detonation was conducted September 10, 1969. Natural gas produced by the well has been flared over several periods since the well was reentered on August 1. Approximately 122 million cubic feet of natural gas have been flared to date.

Project Rulison is a joint government-industry experiment to determine if production of natural gas from a low-permeability formation can be stimulated by a nuclear detonation. Project participants are Austral Oil Co., Inc., the U.S. Atomic Energy Commission, and the Department of the Interior. It is part of the AEC's Plowshare Program to develop peaceful uses for nuclear explosives.

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December 29, 1970

Office of Public Affairs  
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The second phase of the Project Rulison production test flaring program was completed on Sunday, December 20, at 2:03 p.m. MST. About 100 million cubic feet of gas from the nuclear-stimulated well near Grand Valley, Colorado, was flared during the test which started on December 1.

The production test flaring program is being conducted to obtain data to determine the size of the rubble-filled chimney, the area of rock fractured, and the amount of natural gas produced when the 40-kiloton nuclear explosive was detonated 8,400 feet beneath the surface at the site on September 10, 1969. The well was reentered on August 1 and a total of 222 million cubic feet of gas has been flared to date.

The third phase of production test flaring is scheduled to start in from four to six weeks following analysis of data obtained during the second phase and subsequent pressure buildup in the well.

During the production test flaring, radiation surveillance was maintained by the U.S. Environmental Protection Agency (formerly the U.S. Public Health Service). Radiation levels in the air around the site remained well below the radioactivity concentration guidelines. Radiation in the gas at the wellhead has been reduced about 30 percent.

Project Rulison is a joint government-industry experiment to determine if the production of natural gas from a low-permeability formation can be stimulated by a nuclear detonation. Project participants are Austral Oil Co., Inc., the U.S. Atomic Energy Commission, and the Department of the Interior. It is part of the AEC's Plowshare Program to develop peaceful uses for nuclear explosives.

UNITED STATES  
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January 13, 1971

Office of Public Affairs  
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The quality of gas from the Project Rulison well is improving and the amount of radioactivity in the gas is decreasing, according to reports on chemical and radiochemical analyses of the gas recently completed. The very small concentration of radioactivity in off-site areas resulting from flaring (burning) the gas has also been further reduced.

The gas is from a chimney of broken rock formed by a 40-kiloton nuclear detonation on September 10, 1969, about 8,400 feet below the surface at the Project Rulison site near Grand Valley, Colorado. Gas from the well is being flared at various rates and for various lengths of time to determine the effective chimney and fracture volume, the production capability of the well, and the long-term production characteristics of the gas reservoir.

Gas samples are taken from the wellhead periodically during the flaring operations and analyzed by the Environmental Protection Agency's Southwestern Radiological Health Laboratory in Las Vegas; Oak Ridge (Tennessee) National Laboratory; Lawrence Radiation Laboratory in Livermore, California; and by commercial laboratories. Each laboratory's analyses are compared with those of the others to obtain the maximum amount of data. The current data are from gas samples taken on November 3; however, continual radiological monitoring is maintained at the site.

Chemical analysis of the gas is made to determine its quality. The chemical makeup determines how much heat will be produced when the gas is burned. Natural gas containing a large amount of carbon dioxide, for example, will not produce as much heat as gas low in carbon dioxide.

The chemical components in a composite of the gas samples, shown in percentage by volume were: methane--37.70 percent; ethane--2.24 percent; propane--0.54 percent; butane--0.27 percent; other hydrocarbons--0.054 percent; carbon dioxide--43 percent; nitrogen--1.28 percent; hydrogen--14.2 percent.

The amount of carbon dioxide is gradually decreasing as the gas is flared. The level is expected to be about 10 percent when the production test flaring program is completed. The amounts of other chemical components in the gas are typical of the natural gas in the Rulison field.

Radiochemical analysis of the gas shows that radioactivity is decreasing as fresh gas flows into the chimney to replace that being flared. Radioactivity levels in the gas are expected to be considerably less at the end

January 13, 1971

of the third phase of the production test flaring operation which is scheduled to begin in February and continue until spring.

The radioisotopes of major importance are tritium and krypton. The gas now contains 104 picocuries per cubic centimeter of gas of both tritium (hydrogen-3) and krypton-85. The gas contained approximately 175 picocuries per cubic centimeter of gas of each of these isotopes when the well was reentered on August 1, 1970.

Other radioisotopes identified in the gas and their amounts, stated in picocuries per cubic centimeter of gas are: carbon-14, 0.26; argon-37 and 39, 2.1; radon-222, 0.00269; and mercury-203, 0.00001.

Both tritium and krypton have been detected in the air around the Project Rulison site during flaring operations. No radioactivity above background has been found in streams and drinking water in the area. Air and water sampling stations are maintained in the area by the Environmental Protection Agency. During the second production test flaring which ended December 20, the highest amount of tritium measured where anyone lives was from an air sample three miles from the test location. It was 11 picocuries per cubic meter of air. The highest amount of tritium measured in an inhabited area during the first flaring operation in October was 160 picocuries per cubic meter of air. Krypton measurements were about the same.

The radiation concentration guide for tritium is 67,000 picocuries per cubic meter of air and for krypton 100,000 picocuries per cubic meter of air. A curie is a quantity of radioactivity measured by the number of atoms of radioactive substance disintegrating per second. A picocurie is one-millionth of one-millionth of a curie or 2.22 disintegrations per minute.

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Project Rulison is a Plowshare Program experiment to determine the feasibility of stimulating production from a low permeability gas-bearing formation using a nuclear detonation to fracture the rock. Project participants are Austral Oil Company, Inc., the U.S. Atomic Energy Commission, and the Department of the Interior.

NV-71-7

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January 29, 1971

Office of Public Affairs  
2753 South Highland  
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FOR IMMEDIATE RELEASE

The third phase of production test flaring of natural gas from the Project Rulison well is scheduled to begin on February 2. Gas from the nuclear-stimulated well near Grand Valley, Colorado, will be flared (burned) at a rate of 10 to 15 million cubic feet per day for approximately 10 days and then at a reduced rate for up to 80 days.

The production test flaring program is designed to obtain data needed to evaluate the experiment which was conducted to determine how much the production of natural gas from a low-permeability formation can be stimulated by a nuclear detonation.

Data obtained so far indicates that the rubble-filled chimney, created by the 40-kiloton nuclear detonation 8,400 feet beneath the surface conducted on September 10, 1969, is about 270 feet high, 140 feet across and capable of holding more than 200 million cubic feet of gas. About 222 million cubic feet of gas has been flared to date.

During the production test flaring period, radiation surveillance will be maintained for air and water in the area around the site by the Environmental Protection Agency's Southwestern Radiological Health Laboratory (formerly of the U.S. Public Health Service). Radiation released during the flaring is expected to remain at about the same level as for previous flarings, well below the radiation concentration guidelines.

Project Rulison is part of the U.S. Atomic Energy Commission's Plowshare Program to develop peaceful uses for nuclear explosives. Project participants are Austral Oil Co., Inc., the U.S. Atomic Energy Commission, and the Department of the Interior.

NV-71-22

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ADVANCE: HOLD FOR RELEASE  
FOR RELEASE 9:30 A.M. MST,  
APRIL 12, 1971

The natural gas being produced from the Project Rulison well near Grand Valley, Colorado, is continuing to show improvement in quality and a rapid decrease in the concentration of radioactivity contained in the gas.

The latest radiochemical analysis of gas being produced during the third production test flaring at the Rulison well shows radioactivity in the gas has decreased to 1/20th of the level present during the first calibration flaring in October 1970. (Latest levels: krypton-85, 5.1 picocuries per cubic centimeter of gas; tritium, 5.3 picocuries per cubic centimeter of gas.) Analysis of the gas is being conducted by Oak Ridge National Laboratory, Lawrence Radiation Laboratory, and Isotopes, Inc. The gas, which is currently being flared at the approximate rate of 1 million cubic feet per day, was composed of 71 percent methane, 19 percent carbon dioxide, and 10 percent hydrocarbons and gases, at the end of February.

The nuclear explosive, detonated 8,400 feet underground, created a chimney approximately 270 feet high which intersects about 75 feet of gas sands in the Mesaverde formation. The well has produced approximately 210 million cubic feet of gas since the start of the third production flaring test on February 2, 1971. Total gas production from the well is now in excess of 430 million cubic feet. The current production test is expected to end approximately May 1.

Project Rulison is a joint government-industry sponsored experiment to determine if the production of natural gas from a low-permeability formation can be successfully stimulated by a nuclear detonation. Project participants are the U.S. Atomic Energy Commission, Austral Oil Co., Inc., and the Department of the Interior.

Two additional nuclear gas stimulation projects are in the project definition stage. These projects are Rio Blanco, located in the Piceance Basin of western Colorado, and Wagon Wheel in southwest Wyoming.

Rio Blanco is sponsored by CER Geonuclear of Las Vegas, Nevada. The firm plans to have the project definition report completed by late summer.

Project Wagon Wheel has been proposed by El Paso Natural Gas Company. El Paso Natural Gas Company was the first industry sponsor to cooperate with the Atomic Energy Commission in the conduct of a Plowshare project. Project Gasbuggy was conducted near Farmington, New Mexico, in 1967.

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April 23, 1971

Office of Public Affairs  
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FOR IMMEDIATE RELEASE

The third phase of production testing of natural gas from the Project Rulison well was scheduled to end at midafternoon April 23. The third phase started on February 2, 1971. An estimated total volume of 455 million cubic feet of gas will have been flared, or burned, since the well was reentered on August 1, 1970. The production testing program was conducted to obtain data needed to evaluate the success of the experiment.

A 40-kiloton nuclear explosive was detonated 8,400 feet beneath the surface of the Project Rulison site near Grand Valley, Colorado, on September 10, 1969, in an experiment to determine how much the production of natural gas from a low-permeability formation can be stimulated by a nuclear explosion.

The detonation created a rubble-filled chimney estimated to be about 270 feet high, 140 feet across, and capable of holding approximately 200 million cubic feet of gas at reservoir pressures. Preliminary data indicates that the production of natural gas has been enhanced five to ten fold over conventional wells in a comparable gas-producing zone in the Rulison field.

Radioactivity in the gas decreased significantly during the production testing operation. When the well was reentered, the gas contained approximately 175 picocuries per cubic centimeter each of tritium and krypton, the radioactive isotopes of main concern. The gas now contains approximately 3.3 picocuries per cubic centimeter of tritium, and 2.9 picocuries per cubic centimeter of krypton.

The gas was flared at rates as high as 20 million cubic feet per day during high-rate flaring in October to slightly less than one million cubic feet per day at the end of the third flaring period. When the well is shut in, the pressure buildup will be monitored over a long period of time as part of the project evaluation.

After the well is shut in, the site will be cleaned up and placed in a standby condition.

Raw data concerning the production testing program is available in open files. Reports will be made available in the near future. This data has been furnished to the Federal District Court in Denver, Colorado.

A complete evaluation of the success of the project will take several months and results will not be published until the evaluation has been completed. Future plans for the Rulison field will await these results.



April 23, 1971

During the production testing program, the Environmental Protection Agency maintained radiation surveillance of air and water in the area around the site. The measured concentrations of tritium and krypton in air in populated areas lead to the conclusion that it is highly unlikely that anyone received an exposure in excess of one-tenth of one milliroentgen. This is a factor of at least 25 times smaller than the upper limit dose of 2.5 milliroentgens postulated prior to the flaring. Surface water in the area around the site showed no increase in radiation above the normal background level.

Dr. John Emerson, Colorado State Department of Public Health, and his staff performed measurements and analysis in the general area throughout the program. State officials have been kept informed of all test operations and results.

Project Rulison is part of the U.S. Atomic Energy Commission's Plowshare Program to develop peaceful uses for nuclear explosives. Project participants are Austral Oil Co., Inc., the U.S. Atomic Energy Commission, and the Department of the Interior.

UNITED STATES  
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May 17, 1971

Office of Public Affairs  
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Telephone: 734-3851

(NOTE: The following was telephoned to the Colorado press on Friday, May 14, 1971.)

A very small gas leak of approximately one cubic foot per day has developed in the pressure control valve system at the Project Rulison emplacement well near Grand Valley, Colorado.

The leak constitutes no hazard to the public either from the natural gas or from radioactivity. Less than 1 percent of the radioactivity present when the well was completed remains in the gas, and proper ventilation will prevent an explosive mixture from forming.

It is estimated that about 50,000 cubic feet of natural gas will have to be flared to lower the wellhead pressure which now stands at about 1,270 pounds per square inch before repairs can be made. It is expected that the flaring will take less than one day to reduce the pressure to a safe level. Once repairs have been made, the well will be shut in again.

Safety personnel from the AEC and radiation monitors are in the area to assure public safety.

The wellhead is checked twice a day. The leak was discovered at 8 a.m. Friday morning, and steps to stop the leak were promptly started. Repairs are expected to be completed Saturday, May 15.

NV-72-46

UNITED STATES  
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July 11, 1972

Office of Public Affairs  
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Telephone: 734-3851

FOR IMMEDIATE RELEASE

Work is underway to remove production testing equipment from the Project Rulison site six miles southeast of Grand Valley, Colorado. Surface equipment, except for the wellheads, separator unit, and liquid storage tanks, will be removed. Soil and water containing low levels of radioactivity will also be removed. The work is expected to be completed by early August.

Project Rulison was a joint industry Atomic Energy Commission Plowshare Program experiment to determine the feasibility of stimulating the production of natural gas from a low-permeability formation using a nuclear detonation to fracture the rock. The detonation took place on September 10, 1969, about 8,400 feet below the surface of the site. Gas produced by the well was flared (burned) in a production test during the winter of 1970-71.

Low levels of residual radioactivity will be cleaned up and all economically salvageable equipment will be put back into operating condition. Contaminated material will be packaged and taken to the Nuclear Engineering Corporation radioactive waste disposal site near Beatty, Nevada. Some water containing levels of tritium well below Radiation Concentration Guidelines will be steamed to the atmosphere at the site.

The site will be surveyed with sensitive radiation detection instruments to ensure that all contaminated areas are cleaned. The equipment left at the site will be used for long-range monitoring and for possible use if the well is placed into production.

Work at the Rulison site is being done by Austral Oil Company, Inc., the project's industrial sponsor. Following the cleanup, the AEC will continue to inspect the site periodically to ensure compliance with Federal and State environmental regulations.

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APPENDIX E

TECHNICAL INFORMATION  
PLAN

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## APPENDIX E

### TECHNICAL INFORMATION PLAN

- A. A Technical Information Plan outlining the procedures for publishing and disseminating unclassified scientific and technical information relating to Project Rulison was developed and is contained in "Project Rulison Definition Plan" dated March 26, 1969.

B. Plowshare Open File Reports

A significant compilation of scientific and technical information has resulted from Project Rulison.

The bibliography entitled "Reports Available in Plowshare Open File," NVO-86 (Rev. 2), lists those publications concerning Rulison that have been placed in the Plowshare open files by AEC/NV. All of the publications are available to the scientific, technical, and industrial communities. Also listed in the bibliography are certain other publications concerning the AEC's safety programs for underground nuclear detonations which may be of particular interest.

The publications described in NVO-86 (Rev. 2) may be purchased at the following locations:

U.S. Atomic Energy Commission  
Technical Information Center  
Post Office Box 62  
Oak Ridge, TN 37831  
(Check should be payable to  
Microsurance, Inc.)

National Technical Information  
Service  
U.S. Department of Commerce  
Springfield, VA 22151

In addition, these publications are readily available for public inspection in full-size copy at the following locations:

U.S. Bureau of Mines  
Bartlesville Petroleum Research  
Center  
Attn: Open File  
Virginia & Cudahy Streets  
Bartlesville, OK 74003

U.S. Bureau of Mines  
Office of Mineral Resources  
Evaluation  
Library, Building 20  
Attn: Open File  
Denver Federal Center  
Denver, CO 80225

U.S. Atomic Energy Commission  
Nevada Operations Office  
2753 South Highland Drive  
Las Vegas, NV 89102

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APPENDIX F  
OPERATIONAL PROCEDURES FOR RULISON

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I. EVENT, TIME, AND DATE

The Rulison event is scheduled for 1500 hours on September 4, 1969, in hole R-E.

II. LOCATION

The nuclear event will take place near Grand Valley, Colorado, in Garfield County. The SGZ is in the NE 1/4, SW 1/4, Sec. 25, T7S, R95W.

Geographic coordinates are: Longitude 107° 56' 53" W, Latitude 39° 24' 21" N.

III. DIRECTOR OF NUCLEAR OPERATIONS' READINESS BRIEFINGS

## A. Briefings will be held on:

1. D-2 days at 1000 hours MDT in the OCC Trailer at the Control Point.
2. D-1 day at 1930 hours MDT at the Holiday Inn in Grand Junction, Colorado.
3. D-day at 0630 hours MDT at the Holiday Inn in Grand Junction, Colorado.

B. Contractor and Agency Representatives attending the readiness briefings will notify their personnel of the area control plan and any safety precautions recommended by the Director of Nuclear Operations' Advisory Panel and ensure that their respective personnel, not directly connected with the event, are notified to leave the controlled area prior to the final sweep, as indicated in the area control procedures.

IV. AREA CONTROL PROCEDURES

The following plan is scheduled for presentation at the D-1 day readiness briefing. The plan presented will be dependent upon the predicted weather forecast. Modifications may be made by the Director of Nuclear Operations' Advisory Panel prior to H-hour.

- A. H-30 hr Close the Battlement Reservoir Road to southbound traffic.
- B. H-27 hr Commence sweep and clearance of Battlement Reservoir Area.
- C. H-9 1/2 hr Take control of closed areas (0-2.3 miles) and commence muster.

- D. H-9 hr Commence initial sweep of (0-2.3 miles) area.
- E. H-6 hr Complete initial sweep of (0-2.3 miles) area.
- F. H-4 hr Commence final sweep of (0-2.3 miles) area.
- G. H-3 hr Complete final sweep of (0-2.3 miles) area.
- H. H-1 hr Report area clear for arming.
- I. H-30 min Report area clear of ALL personnel.
- J. H-hour Zero time.
- K. H+ The Director of Nuclear Operations will advise when closed areas and roads may be opened to normal traffic.

#### V. MUSTER

- A. All personnel entering or exiting the area within a two (2) mile radius of GZ or south of the CP area are required to stop at the muster or control station for issuance or return of their muster badges.
- B. Contractors and agencies will have all of their personnel not connected with this event out of the closed area prior to the start of the final sweep.
- C. AEC Security will notify OCC when the area is clear for arming.

#### VI. RESPONSIBILITY

- A. The Director of Nuclear Operations is responsible for operational safety for Project Rulison. From the time the explosive arrives at the Rulison site until relieved by the Director of Nuclear Operations, the Operations Director is delegated responsibility for radiological and criticality safety within an area of 800 feet radius from surface ground zero.

The Operations Director or designee will inform the Director of Nuclear Operations at the time when the explosive arrives at Ground Zero. From the time the explosive arrives at the Rulison site, the Operations Director is responsible to the Director of Nuclear Operations for complying with established safety requirements and procedures within the area stated above. Operational guides for radiation exposure and contamination levels are contained in the Safety Plan.

- B. Device Safety and Security Procedures in the GZ area and A&F Control Trailer will be in accordance with AEC Manual Chapter 0560.
- C. When permission to arm is granted, OCC will verify that the Buddy System-is in effect on the A&F Trailer.

## VII. DELAYS

Delays will be announced from the Director of Nuclear Operations Office and will be referenced from the originally scheduled shot time.

## VIII. REENTRY

All postshot reentry teams will be staged at the CP Muster Station and will report to the reentry staging area one hour prior to H-hour. Reentry will start by direction of the Director of Nuclear Operations and all reentries will be coordinated with the Operations Director. The person in charge of each party will give the Security Guard at the Muster Station the item number as listed in the Schedule of Events, names of personnel, and the name of the monitor for the party.

## IX. RADIOLOGICAL SAFETY, REENTRY PERSONNEL

A. Parties entering contaminated, or potentially contaminated, areas, must be accompanied by a qualified Rad-Safe monitor. Arrangements for Rad-Safe monitors may be made with EIC Rad-Safe prior to the event or the laboratory may use its own qualified Rad-Safe monitors.

### B. Instrument Locations

#### 1. RAMS

<u>Station</u>	<u>Bearing</u>	<u>Distance (FT)</u>	<u>Elevation SGZ=0 (FT)</u>
1	N(0°)	300	+20
2	NE(45°)	300	+20
3	E(90°)	300	+40
4	SE(135°)	325	+20
5	S(180°)	300	+20
6	SW(225°)	300	+20
7	W(270°)	300	-40
8	NW(315°)	325	-20
9	Wellhead	0	0
10	CP		

#### 2. Air Sampler

One unit at CP. One unit to SGZ with Reentry Party.

#### 3. Postshot

One RAMS located on Wellhead with recorder through D+6 months or reentry drillback.

4. Termination of RAMS and air sampling units will be at the discretion of the Director of Nuclear Operations.

X. EVACUATION

The Director of Nuclear Operations will determine the necessity for evacuation of all on-site and off-site areas. EPA/NERC and CER personnel in conjunction with local law enforcement officers will evacuate the off-site areas as directed by the Director of Nuclear Operations.

XI. VISITORS

The Observer area for official visitors and invitees will be located approximately 2.3 miles east of Grand Valley and 0.5 miles north of U.S. Highway 6/24, approximately 6.5 air miles northwest of GZ. This area may be used by project personnel not required at the Control Point on D-day. Prior to D-day, agencies must submit names of their personnel to the Joint Office of Information for access to this area. Time for occupancy is prior to H-2 hours. Radio countdown will be provided.

XII. COMMUNICATIONS

- A. At H-4 hours and 15 minutes, all communications on the site radio net will be limited to operational traffic connected with the event and will be controlled by the EPA/NERC net controller.
- B. At H-5 minutes, radio silence will be maintained on all nets except for operational control and emergency traffic. This will remain in effect until announced that normal traffic may resume.

XIII. AIR SPACE CONTROL

With concurrence of FAA, the air space, 5-mile radius from SGZ to 15,000 feet MSL, will be closed from H-4 hours until declared open by the Director of Nuclear Operations after detonation. Additional air space closure may be required if circumstances warrant. Only event-related aircraft will be allowed in the closed air space.

XIV. REPORTS

- A. All technical agencies will keep the Director of Nuclear Operations informed of the status of their programs.
- B. All technical agencies will furnish preliminary results to the Director of Nuclear Operations for inclusion in the H+30 minutes report.
- C. Any additional results will be reported to the Director of Nuclear Operations for inclusion in the H+6 hour report.

XV. MANNED STATIONS

<u>Agency</u>	<u>Location</u>	<u>Comm</u>	<u>Vehicles</u>	<u>Personnel</u>
EPA/NERC	Outside Closed Area	Site Net	Turbo-Beech	To Be Announced
LASL	2000' Upwind 2000' Altitude Above Terrain	USAF	UH1F	To Be Announced

XVI. TECHNICAL STATIONS (INSIDE 5-MILE CONTROLLED AREA)

<u>Agency</u>	<u>Location</u>	<u>Personnel</u>
BLUME	Clem Ranch	Lloyd Lee and R. Johnson
BLUME	Schwab Ranch	William Nelson
BLUME	Lemon Ranch	R. Tapper
BLUME	Battlement School	R. Runge
USGS	Lemon Residence	To Be Announced

XVII. AIRCRAFT PARTICIPATING

<u>Type</u>	<u>Organization</u>	<u>Mission</u>
Turbo-Beech	EPA/NERC	Cloud Tracking/Cloud Sampling
*2-UH1F	WSI	Safety Sweeps
*1-UH1F	LASL	Photo
*1-UH1F	AEC	DONO Standby (Grand Valley)
**Martin 404	EG&G/NATS	Cloud Tracking
**Turbo-Beech	EPA/NERC	Cloud Tracking/Cloud Sampling

\*Two UH1Fs available and will fly multiple missions.

\*\*To be on standby at McCarran Field, Las Vegas, Nevada.

XVIII. CCTV

The closed circuit TV cameras are located:

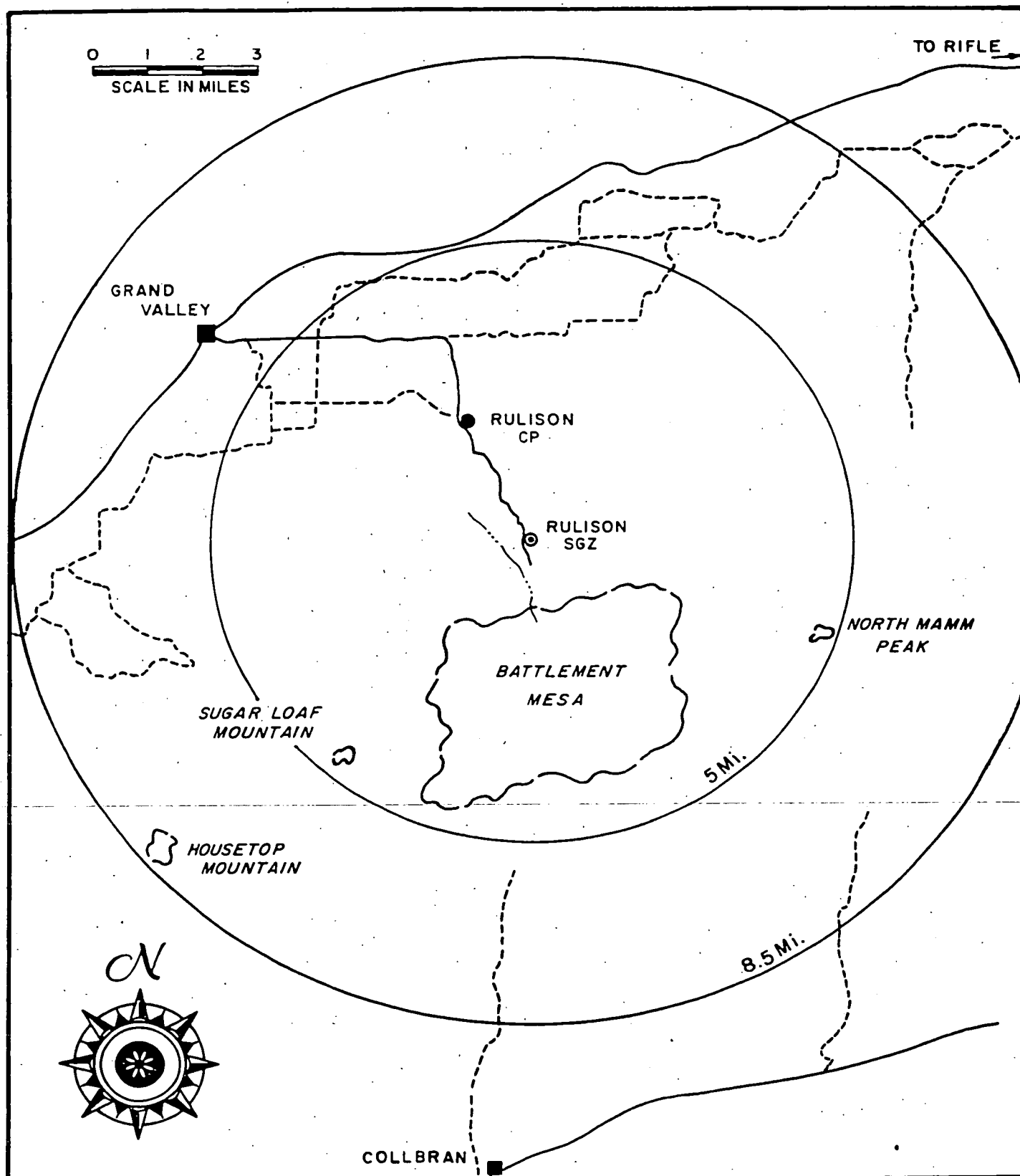
Camera 1	2000' North of GZ
Camera 2	2000' North of GZ

XIX. ABBREVIATIONS

AEC	Atomic Energy Commission
CP	Control Point
DONO	Director of Nuclear Operations
DPNE	Division of Peaceful Nuclear Explosives
EIC	Eberline Instrument Corporation
EPA/NERC	Environmental Protection Agency/National Environmental Research Center
NOAA/ARL	National Oceanic and Atmospheric Administration/Air Resources Laboratory

NOAA/NOS	National Oceanic and Atmospheric Administration/ National Oceanic Survey
FAA	Federal Aviation Administration
GZ	Ground Zero
JOI	Joint Office of Information
LASL	Los Alamos Scientific Laboratory
OCC	Operation Coordination Center
USAF	U.S. Air Force
USBM	U.S. Bureau of Mines
USGS	U.S. Geological Survey
WR	When Released
WSI	Wackenhut Services, Inc.





# SCHEDULE OF EVENTS--RULISON

Item	Hour	Agency	Event
<u>D-2 Days</u>			
1	After Readiness Briefing	DONO	Contact FAA representative, Mr. Dale Backman, Longmont, Colorado, FTS 303-297-3221, and advise as to status of Readiness Briefing.
<u>D-1 Day</u>			
2	0900	WSI/Sheriff Garfield County	Report to CP when southbound traffic on Battlement Reservoir Road (SGZ to top) is stopped by local authorities.
3	0900	WSI	Barricade Battlement Reservoir Bypass Road from lower end to a point .1 mile north of CP.
4	1200	WSI	Two WSI personnel stations 701 & R-71 and one Deputy Sheriff in two vehicles will clear Battlement Mesa of all personnel.
5	After Readiness Briefing	DONO	Contact FAA representative, Mr. Dale Backman, Longmont, Colorado, FTS 303-297-3221, and advise as to status of Readiness Briefing.
6	2000	WSI	Report to CP when sweep and clearance of the Battlement Reservoir (SGZ to top) is completed.
<u>D-Day</u>			
7	H-9 1/2	WSI	Take control of the closed area (0-2.3 miles) muster and commence area control procedures.
8	H-9	WSI	Commence initial sweep of closed area (0-2.3 miles).
9	H-6 hrs	DONO	Contact FAA representative, Mr. Dale Backman, Longmont, Colorado, FTS 303-297-3221, to assure that air space closure is set up for H-4 hours.
10	H-6 hrs	WSI	Complete initial sweep. Report results to CP.

Item	Hour	Agency	Event
11	H-5 hrs	WSI/USAF	Security will accomplish air safety sweep of closed and controlled areas. Aircraft will not fly over GZ area. Two UH1F helicopters will be used. Both will return to Grand Valley pad to refuel and be on station prior to H-15 minutes.
12	H-4 hrs 15 mins	EPA/NERC	EPA/NERC will take control and police the traffic on the site radio net.
13	H-4 hrs 15 mins	EPA/NERC	The EPA/NERC net controller will make a general schedule announcement.
14	H-4 hrs	WSI	Commence final sweep of closed area (0-2.3 miles).
15	<u>Technical Station</u> H-4 hrs	USGS	USGS team will make visual observation of test well at the Lemon Ranch.
16	<u>Technical Station</u> H-4 hrs	BLUME	R. Runge will make visual ground motion effects observations at the Battlement School.
17	<u>Technical Station</u> H-4 hrs	BLUME	R. Tapper will make visual ground motion effects observations at the Lemon Ranch.
18	<u>Technical Station</u> H-4 hrs	BLUME	William Nelson will make visual ground motion effects observations at the Schwab Ranch.
19	<u>Technical Station</u> H-4 hrs	BLUME	Lloyd Lee and Dick Johnson will make visual ground motion effects observations at the Clem Ranch.
20	H-4 hrs	USBM	Two USBM personnel will photograph the wellhead assembly and report to CP when they are clear of the area.
21	H-4 hrs	CER	Position Grand Valley Fire Dept. at Road Block 4, 1 1/2 miles west of Morrisania Community Hall.
22	H-4 hrs	EPA/NERC Garfield County Sheriff	Radio and position check of evacuation teams.

Item	Hour	Agency	Event
23	H-4 hrs	EPA/NERC	Set up road blocks and commence evacuation of 5-mile controlled area. EPA/NERC will report progress to CP periodically.
24	H-3 hrs 45 mins	EPA/NERC	Commence notification of 5-9-mile residents of shot time.
25	H-3 hrs 30 mins	EPA/NERC	The EPA/NERC Net Controller will make a general schedule announcement.
26	H-3 hrs	EPA/NERC	All evacuation teams will report progress of evacuation to CP.
27	H-3 hrs	WSI	Complete final sweep (0-2.3-mile area) report results and area count (by name and organization) to CP.
28	H-2 hrs 45 mins	EPA/NERC	Radio and position check of EPA/NERC team at Rifle School.
29	H-2 hrs 45 mins	EPA/NERC	Radio and position check of EPA/NERC team at Collbran School.
30	H-2 hrs 45 mins	CER/EPA/NERC	Radio and position check of EPA/NERC team at Grand Valley School. EPA/NERC will report to CP.
31	H-2 hrs 45 mins	EPA/NERC	Radio and position check of EPA/NERC team at Anvil Points Facility.
32	H-2 hrs 45 mins	EPA/NERC	Radio and position check of EPA/NERC team at Union Carbide Plant.
33	H-2 hrs 30 mins	EPA/NERC	The EPA/NERC Net Controller will make a general schedule announcement.
34	H-2 hrs 30 mins	Mesa County Sheriff/County Road Dept.	County roadblock and maintenance personnel will report to CP that they are on station and awaiting activation orders.
35	H-2 hrs 30 mins	Garfield County Sheriff/County Road Dept.	County roadblock and maintenance personnel will report to CP that they are on station and awaiting activation orders.
36	H-2 hrs 30 mins	CHP/State Highway Dept.	State Highway roadblock and maintenance personnel will report to CP that they are on station and awaiting activation orders.

Item	Hour	Agency	Event
37	H-2 hrs	CER	Shift power for critical circuits at the CP to generator power.
38	H-2 hrs	EPA/NERC	Verify 0-5-mile area cleared except for technical area stations.
39	H-2 hrs	KWSR	Radio Station KWSR, located in Rifle, Colorado, will begin continuous broadcast on 810 Kilohertz, with information concerning Project RULISON.
40	H-2 hrs	Suburban Gas Co./EPA/NERC	Personnel from the Suburban Gas Company will have disconnected gas service in the evacuated area and reported to EPA/NERC. EPA/NERC will report to CP.
41	H-2 hrs	Western Slope Gas Co./EPA/NERC	Personnel from the Western Slope Gas Company will have disconnected gas service in the evacuated area and reported to EPA/NERC. EPA/NERC will report to CP.
42	H-2 hrs	Holy Cross Electric Assn./EPA/NERC	Personnel from the Holy Cross Electric Association will have disconnected electrical service in the evacuated area and reported to EPA/NERC. EPA/NERC will report to CP.
43	H-2 hrs	WSI	Activate access control on OCC trailer. <del>Admittance will be by</del> access list and VO authority.
44	H-2 hrs	AEC	A Readiness Briefing will be conducted in the OCC trailer at the Rulison site.
45	H-2 hrs	WSI	Report to CP when closed area is clear of all personnel except arming party and USGS at test well.
46	H-1 hr 45 mins	EPA/NERC	Radio and position check for downwind monitoring teams.
47	H-1 hr 30 mins	EPA/NERC	The EPA/NERC Net Controller will make a general schedule announcement.

Item	Hour	Agency	Event
48	H-1 hr 30 mins	CHP	STATE HIGHWAY ROADBLOCK S5: The Colorado Highway Patrol will block U.S. 6 and 24 NE and SW approaches to community of Grand Valley. They will then report to CP.
49	H-1 hr 30 mins	Garfield County Sheriff	COUNTY ROADBLOCK G2: The Garfield County Sheriff will block NW and SE approaches to community of Grand Valley. Report to CP through the Colorado Highway Patrol Net.
50	H-1 hr 30 mins	CHP	STATE HIGHWAY ROADBLOCK S1: The Colorado Highway Patrol will block and sweep Interstate 70 in the Book-cliffs area west of Palisade and roads (U.S. 6 & 24) south and east of Palisade. CHP will then report to CP.
51	H-1 hr 30 mins	CHP	STATE HIGHWAY ROADBLOCK S2: The Colorado Highway Patrol will block and sweep Interstate 70 through DeBeque Canyon and report to CP.
52	H-1 hr 30 mins	CHP	STATE HIGHWAY ROADBLOCK S3: The Colorado Highway Patrol will block and sweep Highway 65 through Plateau Creek Canyon and report to CP.
53	H-1 hr 30 mins	CHP	STATE HIGHWAY ROADBLOCK S12: The Colorado Highway Patrol will block and sweep U.S. Highways 6 and 24 through Glenwood Canyon. CHP will report to CP.
54	H-1 hr 30 mins	Garfield County Sheriff	COUNTY ROAD ROADBLOCK G1: The Garfield County Sheriff will block and sweep Parachute Creek Road starting from about 5 miles north of Grand Valley to end of road. Report to CP through the Colorado Highway Patrol Net.
55	H-1 hr 30 mins	Garfield County Sheriff	TOSCO OIL SHALE FACILITY: The TOSCO Oil Shale Facility will be evacuated. Garfield County Sheriff will verify and report to CP.

Item	Hour	Agency	Event
56	H-1 hr 30 mins	Garfield County Sheriff	COUNTY ROAD ROADBLOCK G3: The Garfield County Sheriff will block approach (from 6 and 24) to community of Rulison. Report to the CP through the Colorado Highway Patrol Net.
57	H-1 hr 15 mins	EPA/NERC	Report status of 5-9-mile resident check to CP.
58	H-1 hr	LASL/WSI	A security sweep will be conducted with the photo helicopter. Helicopter to be on photo station at H-15 minutes.
59	H-1 hr	LASL	Operations Director requests permission to arm.
60	H-1 hr	AEC	Director of Nuclear Operations gives permission to arm.
61	H-1 hr	WSI	The buddy system will be established at the arming and firing trailer.
62	H-1 hr	LASL	The arming party will enter the GZ area and relieve Security Stations 705 and 705-C. The arming party will proceed with final check on cables, arm the device, and return to the CP.
63	H-1 hr	WSI	WSI Stations 705 and 705-C, when relieved by arming party, will relocate to arming and firing trailer at CP.
64	H-1 hr	EPA/NERC	Commence evacuation of schools.
65	H-1 hr	CHP	STATE HIGHWAY ROADBLOCK, DAVIS POINT: The Colorado Highway Patrol will block and sweep a section about 0.5 mile long of Highways 6 and 24 about one mile east of Silt, Colorado.
66	H-1 hr	D&RGWR	The representative of the Denver and Rio Grande Western Railroad will make preparations to stop train traffic through potential rockfall areas until after the posthot track check. The representative will communicate directly with the line dispatcher via the D&RGWR Radio Net and will keep CP informed.

Item	Hour	Agency	Event
67	H-1 hr	CHP	STATE HIGHWAY ROADBLOCK S4: The Colorado Highway Patrol will block and sweep a section of C-330 about 2.5 miles east of Molina. The CHP will report to CP.
68	H-1 hr	CHP	STATE HIGHWAY ROADBLOCK S8: The Colorado Highway Patrol will block and sweep Colorado State Highway 325, Rifle Gap Road, and east and west approaches to Rifle Gap Dam. CHP will report to CP.
69	H-1 hr	CHP	STATE HIGHWAY ROADBLOCK S9: The Colorado Highway Patrol will block and sweep a section of U.S. Highways 6 and 24 west of New Castle. CHP will report to CP.
70	H-1 hr	CHP	STATE HIGHWAY ROADBLOCK S10: The Colorado Highway Patrol will block and sweep two short sections of U.S. Highways 6 and 24 east of New Castle. CHP will report to CP.
71	H-1 hr	CHP	STATE HIGHWAY ROADBLOCK S11: The Colorado Highway Patrol will block and sweep a section about 3.5 miles long on U.S. Highways 6 and 24 west of Glenwood Springs. CHP will report to CP.
72	H-1 hr	CHP	STATE HIGHWAY ROADBLOCK S13: The Colorado Highway Patrol will block and sweep Colorado State Highway 82 beginning about 2.5 miles south of junction with U.S. 6 and 24 and continuing for about four miles south. CHP will report to CP.
73	H-1 hr	CHP	STATE HIGHWAY ROADBLOCK S14: The Colorado Highway Patrol will block and sweep a section of C-82 about 1.7 miles long, extending either side of junction with C-133. CHP will report to CP.



Item	Hour	Agency	Event
74	H-1 hr	Garfield County Sheriff	COUNTY ROAD ROADBLOCK G4: The Garfield County Sheriff will block and sweep Harvey Gap Road from mouth of canyon to top of dam. Report to the CP through the Colorado Highway Patrol Net.
75	H-1 hr	Garfield County Sheriff	COUNTY ROAD ROADBLOCK G5: The Garfield County Sheriff will block and sweep East Elk Creek Road from junction with West Elk Creek Road north to U.S. Forest boundary. Report to the CP through the Colorado Highway Patrol Net.
76	H-1 hr	Garfield County Sheriff	COUNTY ROAD ROADBLOCK G6: The Garfield County Sheriff will block and sweep South Canyon Road from Colorado River south for one mile. Report to the CP through the Colorado Highway Patrol Net.
77	H-1 hr	Garfield County Sheriff	COUNTY ROAD ROADBLOCK G7: The Garfield County Sheriff will block and sweep Red Canyon Road from junction with C-82 to about two miles up Red Canyon. Report to CP through the Colorado Highway Patrol Net.
78	H-1 hr	Mesa County Sheriff	COUNTY ROAD ROADBLOCK M1: The Mesa County Sheriff will block and sweep the DeBeque-Collbran Cut-Off Road. Report to CP through the Colorado Highway Patrol Net.
79	H-1 hr	Mesa County Sheriff	COUNTY ROAD ROADBLOCK M3: The Mesa County Sheriff will block and sweep the Vega Reservoir Road. Report to the CP through the Colorado Highway Patrol Net.
80	H-50 mins	EPA/NERC	Verify Anvil Points Facilities clear including Mobil Oil and USBM installations.
81	H-45 mins	D&RGWR	D&RGWR representative advises the Director of Nuclear Operations that all trains are stopped and out of hazardous areas and sweep patrols and work train are on station.

Item	Hour	Agency	Event
82	H-45 mins	EPA/NERC	Verify Grand Valley School evacuated.
83	H-45 mins	EPA/NERC	Verify Rifle School evacuated.
84	H-45 mins	EPA/NERC	Verify Collbran School evacuated.
85	H-45 mins	Garfield County Sheriff	COUNTY ROAD ROADBLOCK G8: The Garfield County Sheriff will have standby personnel on the Silt-Collbran Cut-Off Road. Standby roadblock to be used only if ordered. Report to CP through the Colorado Highway Patrol Net.
86	H-45 mins	Mesa County Sheriff	COUNTY ROAD ROADBLOCK M4: The Mesa County Sheriff will have standby personnel on the Silt-Collbran Cut-Off Road. Standby roadblock to be used only if ordered. Report to the CP through the Colorado Highway Patrol Net.
87	H-45 mins	Mesa County Sheriff	COUNTY ROAD ROADBLOCK M5: The Mesa County Sheriff will have standby personnel on the Buzzard Creek Road near the Delta County line. Standby roadblock to be used only if ordered. Report to the CP through the Colorado Highway Patrol Net.
88	H-45 mins	EPA/NERC	Union Carbide team position and radio check with CP.
89	H-45 mins	CER	RIFLE CREEK VANADIUM MINE: CER will verify that mine is evacuated and report to CP.
90	H-45 mins	CER	HARVEY GAP 3 COAL MINE: CER will verify that mine is evacuated and report to CP.
91	H-45 mins	CER	NU GAP COAL MINE: CER will verify that mine is evacuated and report to CP.
92	H-45 mins	CER	BASIC CHEMICAL LIMESTONE MINE: CER will verify that mine is evacuated and report to CP.
93	H-45 mins	CER	GLENWOOD LIMESTONE MINE: CER will verify that the mine is evacuated and report to CP.

Item	Hour	Agency	Event
94	H-45 mins	CER	NEW SOUTH CANYON COAL MINE: CER will verify that mine is evacuated and report to CP.
95	H-45 mins	CER	FOUR MILE COAL MINE: CER will verify that the mine is evacuated and report to CP.
96	H-45 mins	CER	DUTCH CREEK 2 COAL MINE: CER will verify that mine is evacuated and report to CP.
97	H-45 mins	CER	SOMERSET COAL MINE: CER will verify that the mine is evacuated and report to CP.
98	H-45 mins	CER	HAWKS NEST COAL MINE: CER will verify that the mine is evacuated and report to CP.
99	H-45 mins	CER	BLACK BEAUTY COAL MINE: CER will verify that the mine is evacuated and report to CP.
100	H-45 mins	CER	BEAR COAL MINE: CER will verify that the mine is evacuated and report to CP.
101	H-45 mins	CER	KING COAL MINE: CER will verify that the mine is evacuated and report to CP.
102	H-45 mins	CER	GREEN VALLEY 2 MINE: CER will verify that the mine is evacuated and report to CP.
103	H-45 mins	CER	RED CANYON 1 COAL MINE: CER will verify that the mine is evacuated and report to CP.
104	H-45 mins	CER	TOP COAL MINE: CER will verify that the mine is evacuated and report to CP.
105	H-45 mins	CER	BLUE FLAME MINE: CER will verify that the mine is evacuated and report to CP.
106	H-45 mins	CER	GO-BOY COAL MINE: CER will verify that the mine is evacuated and report to CP.

Item	Hour	Agency	Event
107	H-45 mins	CER	ROADSIDE COAL MINE: CER will verify that the mine is evacuated and report to CP.
108	H-45 mins	CER	CAMEO COAL MINE: CER will verify that the mine is evacuated and report to CP.
109	H-45 mins	CER	GEARHART COAL MINE: CER will verify that the mine is evacuated and report to CP.
110	H-45 mins	CER	COAL CANYON STRIP MINE: CER will verify that the mine is evacuated and report to CP.
111	H-45 mins	CER	McGINLEY 2 COAL MINE: CER will verify that the mine is evacuated and report to CP.
112	H-45 mins	CER	L. S. WOOD COAL MINE: CER will verify that the mine is evacuated and report to CP.
113	H-40 mins	EPA/NERC/CER	Verify Rulison Community residents are outdoors and in safe locations.
114	H-40 mins	EPA/NERC/CER	Verify Grand Valley residents are outdoors and in safe locations.
115	H-30 mins	USGS	USGS personnel will have completed work at test well, south of CP, and will have exited closed area.
116	H-30 mins	WSI	Security will report to the Director of Nuclear Operations through the Operations Coordination Center that the closed area is clear of all personnel.
117	H-30 mins	EPA/NERC	The EPA/NERC Net Controller will transmit wind data to aircraft.
118	H-30 mins	EPA/NERC	RURAL EVACUATION GROUPS (5-9 MILES): EPA/NERC evacuation teams report to CP that all personnel are in safe locations.
119	H-30 mins	LASL	The arming party will report to Directors of Nuclear Operations when arming is complete and departing area.

Item	Hour	Agency	Event
120	H-30 mins	EPA/NERC	EPA/NERC Turbo-Beech will be on station for cloud tracking and sampling at the direction of the Director of Nuclear Operations. Net 12 A/G.
121	H-30 mins	EG&G/NATS	NATS aircraft and crew will be on station and will be controlled by the Director of Nuclear Operations. Net 12 A/G.
122	H-30 mins	LASL	The Operations Director will request permission to fire the Rulison device.
123	H-30 mins	DONO	The Director of Nuclear Operations gives permission to fire.
124	H-30 mins	LASL	Countdown will be initiated on site radio net.
125	H-15 mins	LASL/WSI	One UH1F helicopter will be used by LASL for photo purposes. Aircraft will be positioned at an altitude of 2,000 feet above terrain and 2,000 feet upwind.
126	H-5 mins	ALL	Radio silence will be maintained on all nets, except for operational control and emergency traffic. Radio silence will be lifted when directed by net control.
127	H-hour	ALL	Zero time.
128	When directed by DONO	EIC	The following personnel, in anti-C clothing, will conduct the initial radiological survey of SGZ: R. L. Powell, A. Nelson, N. Parmeter, M. Underwood, L. Oxsheer, D. Greene, L. Brown, W. Petrochko, L. Jewett, and I. Wilson.
129	When directed by DONO	AEC	Railroad and highway personnel commence inspections to determine condition of roadways. Report conditions to CP.
130	When directed by DONO	AEC	The Director of Nuclear Operations will advise when roads and closed areas may be opened.

Item	Hour	Agency	Event
131	When directed by DONO	LASL/SER	The Operations Director's party will proceed to GZ in anti-C clothing (if required) to survey postshot conditions. List to be furnished by LASL at a later date, with VO authorities.
132	When directed by DONO	USBM	Two USBM personnel will photograph the wellhead assembly for post-event documentation.

APPENDIX G

PROJECT RULISON  
OPERATING INSTRUCTIONS  
REENTRY DRILLING AND PRODUCTION TESTING

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## APPENDIX G

### PROJECT RULISON OPERATING INSTRUCTIONS REENTRY DRILLING AND PRODUCTION TESTING

The following operating instructions are for use by DONO or his delegated representative during the Rulison reentry and production testing operations. These instructions provide acceptable operating limits for release of radioactivity to implement the radiation protection standards specified in the Rulison Operations Plan. Additions or modifications to these instructions will be made only as necessary and must be approved by DONO.

The operating limits are based on concentration levels determined by individual onsite and offsite effluent monitoring systems. These systems are listed below.

#### INDIVIDUAL MONITORING SYSTEMS

##### A. System to Analyze Low Levels of Krypton and Tritium (STALLKAT)

This instrument continuously measures tritium and krypton-85 concentrations within the natural gas stream at the point of release.

##### B. U.S. Bureau of Mines Type Detection System

Although using a different type detector than STALLKAT, this system will also be used for on-line monitoring of the gas stream. It is expected that this system will ultimately replace the STALLKAT at Rulison after checkout.

##### C. Gross Gamma Detection System

The Geiger-Mueller detector for this unit is placed on the stack line to measure gamma-emitting radionuclides contained in the gas stream.

##### D. Particulate Monitoring System

This system draws gas continuously from the stack line through a high-efficiency particulate filter and a charcoal filter. The filters are periodically changed and analyzed for beta and gamma activity.

##### E. Mobile Tritium Detectors

The EPA/NERC will field mobile tritium detectors in downwind populated areas. These instruments are capable of determining instantaneously tritium concentrations.

#### F. Action Concentration Levels

For each of the above monitoring systems an action concentration level has been developed. Should any one of these values, listed in the table below, be attained during either the reentry drilling or production testing, operations will be stopped until collection and evaluation of additional data indicates that the operation can proceed.

<u>Detection System</u>	<u>Action Guide Level</u>
STALLKAT/USBM	$7.5 \times 10^{-3}$ $\mu\text{c/cc}$ (tritium) $7.5 \times 10^{-4}$ $\mu\text{c/cc}$ (krypton)
Gross Gamma	$10^{-4}$ $\mu\text{c/cc}$
Particulate (paper)	$4 \times 10^{-9}$ $\mu\text{c/cc}$
Particulate (charcoal)	$10^{-10}$ $\mu\text{c/cc}$
Mobile Tritium Detectors (PHS)	$10^{-5}$ $\mu\text{c/cc}$

#### G. Other Monitoring Systems

The monitoring systems described in the preceding sections will be used as action controls for the reentry and production testing operations. In addition, the EPA/NERC will field other air monitoring systems which are capable of measuring tritium and other isotopes in air to much lower levels than those listed above. These will be used for documentation and for the public exposure calculation.

EPA/NERC will also monitor radiation levels in water and foodstuffs. Results of these EPA/NERC monitoring efforts and the air monitoring data will be used to calculate cumulative exposure records for the close-in offsite residents. This record will show the cumulative dose commitment from sources of exposure. The record will be intermittently updated and should the estimated dose commitment rate for any locality exceed the expected dose, a report will be made to DONO for further instruction.

Units in $\mu\text{Ci/cc}$								
	Expected Concentration in Gas	Shut-down Level	Lower Limit of Detection	Upper Limit of Detection	Detection System	Probable Dilution Factor for Downwind Points of Maximum Concentration	Shut-down Level Divided by Probable Dilution Factor	Radiation Concentration Guide (Air) for Offsite Population
Tritium	$7.5 \times 10^{-4}$	$75 \times 10^{-4}$	$0.2 \times 10^{-4}$	$25,000 \times 10^{-4}$	STALLKAT/USBM <sup>a,c</sup>	$10^5 - 10^6$	$7.5 \times 10^{-8}$ to $7.5 \times 10^{-9}$	$6.7 \times 10^{-8}$
Krypton-85	$7.5 \times 10^{-5}$	$75 \times 10^{-5}$	$0.013 \times 10^{-5}$	$1100 \times 10^{-5}$	STALLKAT/USBM	$10^5 - 10^6$	$7.5 \times 10^{-9}$ to $7.5 \times 10^{-10}$	$10^{-7}$
Cesium-137	None	$10^{-4}$	$10^{-5}$	$1000 \times 10^{-4}$	Gross Gamma <sup>b,c</sup>	$10^5 - 10^6$	$10^{-9}$ to $10^{-10}$	$8.3 \times 10^{-11}$
Strontium-90 Cesium-137	None	$4 \times 10^{-9}$	$4 \times 10^{-9}$	---	Particulate (High efficiency filter) sample	$10^5 - 10^6$	$4 \times 10^{-14}$ to $4 \times 10^{-15}$	$10^{-11}$
Iodine-131	None	$10^{-10}$	$10^{-10}$	---	Particulate (Charcoal cartridge) sample	$10^5 - 10^6$	$10^{-15}$ to $10^{-16}$	$3.3 \times 10^{-11}$

- a. Detection levels for USBM-type system are assumed to be the same as for the STALLKAT.
- b. Gross-gamma system detects gamma-emitting radionuclides passing through the gas line whose gamma energy is sufficient to penetrate the line wall and enter the detector. The system, therefore, while calibrated for Cesium-137 can also measure other radionuclides.
- c. Statistical and electrical fluctuations may cause a factor of 10 variation about the mean value for the STALLKAT/USBM and gross-gamma systems.

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